TRANSMISSION APPARATUS WITH A FUNCTION TO SWITCH

A LINE IN THE EVENT OF A TRANSMISSION FAILURE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to switching control executed by a transmission apparatus such as a BLSR (Bi-directional Line Switched Ring) multiplexing apparatus having a function to switch a line in the event of a transmission failure.

Description of the Related Art

In a network including a BLSR multiplexing apparatus, a transmission line is designed into a redundant configuration comprising a working line and a protection line. If a failure occurs on the working line, the transmission line is switched to the protection line for transmissions in a direction opposite to the working line so as to improve reliability of the network. The working line is a line that is used when no failure occurs. The protection line is a line to which the transmission is switched from the working line in the event of a failure on the working line. This BLSR multiplexing apparatus is used as an apparatus for transmitting data such as voices and pictures in a

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synchronous network such as an SDH (Synchronous Digital Hierarchy) network. In the case of a BLSR multiplexing apparatus, a band between addition of a signal to a transmission line and dropping of the signal from the transmission line accommodating a terminal on the reception side is allocated to the transmission line as a channel. Since the channel is never allocated to the transmission line once the data has been dropped from the line, however, the transmission capacity of 1 optical fiber is, on the average, 1.5 times that of a transmission apparatus used so far with the channel occupying a transmission line of 1 ring cycle. The addition of a signal to a transmission line cited above is an operation to transmit the data output by a terminal on the transmission side through the line. On the other hand, the dropping of a signal is an operation to transmit the added signal to a transmission line connected to a terminal on the reception side or another ring.

In particular, in a 4-fiber BLSR multiplexing apparatus, each transmission line is a shared line used as both a working line and a protection line. A 4-fiber BLSR multiplexing apparatus is used in conjunction with 4 transmission lines, namely, 2 working lines and 2

protection lines. Each of the 4 transmission lines is a physically separated fiber. In comparison with a 2-fiber BLSR multiplexing apparatus, a 4-fiber BLSR multiplexing apparatus has a span-switch function in addition to a ring switch for switching a transmission from a working line to a protection line in the event of a failure on the working line. It is thus quite within the bounds of possibility that the network is rescued from a line failure. Accordingly, the demand for a 4-fiber BLSR multiplexing apparatus is rising. In addition to the conventional multiplexing apparatus, for the BLSR multiplexing apparatus, there have been discussed a network configuration for transmission over a long distance through a sea-bottom cable and a switching technique referred to as a submarine BLSR. By carrying out a switching operation according to an adopted technique in the event of a failure on a transmission line, suspension of a signal transmission can be avoided.

In order to execute switching control in the event of a failure in a conventional BLSR multiplexing apparatus which is also referred to as an NE (Network Element), every BLSR multiplexing apparatus is provided with a ring topology table and a squelch table showing a range of cross-connected working lines for each channel

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such as an STS1 or VC3 channel. A ring topology table is a table showing a connection order of NEs connected to form a ring in a direction toward an east side starting with the node ID of this station. The direction toward the east side is defined typically as a counterclockwise direction along the ring. A node ID is an ID assigned to each NE uniquely in the network. By referring to a ring topology table, each NE is capable of knowing the node ID of an adjacent NE.

A squelch table is a table used in a BLSR multiplexing apparatus for forming a judgment as to whether or not to insert an AIS signal into a circuit that cannot be rescued from failures when the failures occur on a plurality of transmission lines in order to avoid incorrect connection. Information stored in a squelch table includes the ID of a signal-adding NE and the ID of an NE dropping the signal. In this squelch table, an add channel and a drop channel are set individually only for each working line. An add channel is the channel of one of 2 working lines, which is used for transmitting added data. A drop channel is the channel of a line dropping a signal. The node ID of a signal-adding NE is referred to as a source-node ID. On the other hand, the node ID of a signal-dropping NE is

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referred to as a destination-node ID.

The user enters cross-connect information for each channel to an NE on the channel. The cross-connect information includes Add, Drop or Through (or Relay) and the direction of the signal such as East or West. Each NE stores a source-node ID or a destination-node ID in a SONET or SDH overhead byte to be used in creation of a squelch table, and transmits as well as receives node IDs in accordance with the following rule. A transmission table and a reception table are provided in a squelch table for an add channel and a drop channel respectively. The transmission table is a table that is used for storing a node ID when the node ID is transmitted. On the other hand, the reception table is a table that is used for storing a node ID when the node ID is received.

A signal-adding NE sets the node ID of its own as a source-node ID in the transmission table for the channel used for transmitting the added data. The signal-adding NE stores a received destination-node ID in a destination entry of the transmission table and a destination entry of the reception table before bouncing back the destination-node ID to the adjacent NE. The signal-adding NE stores a source-node ID bounced back by a signal-dropping NE in the reception table. A data-passing-

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through NE passes on a received node ID to an adjacent NE
as it is. A signal-dropping NE sets a destination-node ID
in a transmission table for a signal-dropping channel.
The signal-dropping NE stores a received source-node ID
in a source entry of the transmission table and a source
entry of the reception table before bouncing back the
source-node ID to the adjacent NE. The signal-dropping NE
stores a source-node ID bounced back by a signal-dropping
NE in the reception table. Each NE determines that the
creation of a squelch table has been completed when the
transmission table is found to match the reception table.
If the transmission table does not match the reception
table, on the other hand, incorrect setting is determined
to exist. In this way, incorrect setting of each channel
can be avoided. In addition, an AIS signal is inserted
into a circuit that cannot be rescued from failures when
the failures occur on a plurality of transmission lines,
making it impossible to carry out communications between
a signal-adding NE and a signal-dropping NE, which are
set in the squelch table.

A submarine BLSR multiplexing apparatus supports a
drop-and-continue connection as an inter-ring connection.
A drop-and-continue connection is a connection by which a
primary node drops a transmitted signal to an adjacent

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ring network and, at the same time, relays the signal to an adjacent NE. Two drop-and-continue options are available. One of the options is selected for passing through a secondary circuit of a redundant system to a working line and the other option is selected for passing through a secondary circuit of a redundant system to a protection line. The former is referred to as a DCW (Drop and Continue on Working) connection while the latter is referred to as a DCP (Drop and Continue on Protection) connection. In a DCP connection, the primary node drops a signal from transmission to an adjacent ring network but continues the signal to a protection line before a secondary node drops the signal from transmission to the adjacent ring network. In a DCP connection, a primary node is a node that is connected to an adjacent ring network and plays roles to drop a working signal from transmission to the adjacent ring network and continue the signal to a protection line. On the other hand, a secondary node in a DCP connection is a node that is connected to an adjacent ring network and plays a role to drop a working signal from transmission to the adjacent ring network through a protection line.

In a DCW connection, on the contrary, the primary node drops a signal from transmission to an adjacent ring

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network but continues the signal to a working line before a secondary node drops the signal from transmission to an adjacent ring network. In a DCW connection, a primary node is a node that is connected to an adjacent ring network and plays roles to drop a working signal from transmission to the adjacent ring network and continue the signal to the working line. On the other hand, a secondary node in a DCP connection is a node that is connected to an adjacent ring network and plays a role to drop a working signal from transmission to the adjacent ring network through the working line.

As another implementation of connection between ring networks, there is provided a DTP (Dual Terminal Transmit on Protection) connection in which a terminal node accommodating a terminal adds a signal to a working line as well as a protection line, a primary node drops a signal from a working line and a secondary node drops a signal from the protection line. As further implementation of connection between ring networks, there is also provided a DTW (Dual Terminal Transmit on Working) connection in which a terminal node accommodating a terminal adds a signal to a working line and a secondary node drops a signal from the working line.

However, the conventional BLSR multiplexing

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apparatus has the following problems:

1: Since a squelch table is created as a collection of only source-node IDs and destination-node IDs, it is not possible to express a variety of implementations of connection such as the DCW connection and the DCP connection. Thus, for example, a connection of switching in the event of a failure for the DCW connection is the same as that for the DCP connection, making it impossible to carry out a switching operation according to the implementation of connection.

2: A squelch table is created as a collection of only node IDs of signal-adding NEs connected to working lines and signal-dropping NEs also connected to working lines without collecting node IDs of secondary nodes connected to protection lines. Since squelching control is executed in accordance with such a squelch table, an unnecessary squelching operation is executed for a DCP connection or a DTP connection even if the network can be rescued from a transmission-line failure.

3: Since a connection is checked incorrectly due to the fact that only node IDs are collected, it is not possible to easily check whether or not a node ID of a node between destination and source nodes is correctly set. It is thus also impossible to carry out a complex checking

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operation according to the implementation of connection such as the DCP or DCW connection.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a transmission apparatus capable of carrying out a switching operation according to an implementation of connection in the event of a failure.

It is another object of the present invention to provide a transmission apparatus capable of properly rescuing the network from a line failure by forming a proper judgment as to whether or not to carry out a squelching operation according to an implementation of connection in the event of the failure.

It is a further object of the present invention to provide a transmission apparatus capable of offering higher reliability by checking a connection of a line definition according to an implementation of connection.

In accordance with an aspect of the present invention, there is provided a transmission apparatus having a function to switch a line with a redundant configuration comprising a working line and a protection line from the working line to the protection line in the event of a transmission-line failure on the working line,

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the transmission apparatus comprising: a cross-connect-classifying means for inputting cross-connect information from an external source and classifying the information into cross-connect categories wherein the cross-connect information includes a signal direction and information requesting a station employing the transmission apparatus to carry out one of the following pieces of processing for each channel: addition of a signal to either the working line or the protection line; addition of a signal to both the working line and the protection line; dropping of a signal from either the working line or the protection line; dropping of a signal from both the working line and the protection line; passing-through of a signal; and dropping of a signal from either the working line or the protection line and then relaying the signal to either the working line or the protection line; a communication means for gathering the cross-connect category of each signal-adding or signal-dropping transmission apparatus of a channel and node information identifying the signal-adding or signal-dropping transmission apparatus by communications with an adjacent transmission apparatus for each channel; a connection-implementation-classifying means for classifying implementations of connection into appropriate connection

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categories in accordance with gathered cross-connect

categories of other transmission apparatuses and the

cross-connect category of the transmission apparatus

employed in the station to create a table for executing

control to switch a line in the event of a failure for

each channel; a failure-reporting means for transmitting

information on a failure including node information of

the station in the event of a failure on a transmission

line between the station and an adjacent station; a

failure-occurrence-location-identifying means for

identifying the location of occurrence of a failure from

received information on the failure; and a switching

control means for executing control to switch the line

based on a location of occurrence of a failure identified

by the failure-occurrence-location-identifying means and

the table.

It is desirable to provide a connection-

implementation-classifying means that detects incorrect

setting on the basis of an order in which the cross-

connection categories are collected. For each channel, it

is desirable to provide a connection-implementation-

classifying means that creates a squelch table composed

of node information of 2 stations and, in the case of a

DCP connection of dropping a signal from a line and then

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relaying the signal to the protection line, it is

desirable to have the connection-implementation-

classifying means set node information of a station

dropping the signal relayed to the protection line in the

squelch table whereas, in the case of a DTP connection of

adding a signal to both the working and protection lines,

it is desirable to have the connection-implementation-

classifying means set node information of a first station

adding the signal to both the working and protection

lines and node information of a second station dropping

the signal added to the protection line in the squelch

table. It is desirable to provide a connection-

implementation-classifying means that creates a RIP table

including node information of a station adding a signal,

dropping a signal or relaying after dropping a signal and

path information for the implementation of connection for

each channel. It is desirable to provide a switching

control means that executes switching control for the

implementation of connection based on the path

information.

The above and other objects, features and

advantages of the present invention as well as the manner

of realizing them will become more apparent, whereas the

invention itself will be best understood from a study of

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the following description and appended claims with

reference to attached drawings showing some preferred

embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram showing the principle of the

present invention;

Fig. 2 is a diagram showing the configuration of a

network provided by a first embodiment of the present

invention;

Fig. 3 is a diagram showing a normal connection of

the network shown in Fig. 2;

Fig. 4 is a diagram showing the configuration of a

network provided by a second embodiment of the present

invention;

Fig. 5 is a diagram showing a DTW connection of the

network shown in Fig. 4;

Fig. 6 is a diagram showing the configuration of a

network provided by a third embodiment of the present

invention;

Fig. 7 is a diagram showing a DTP connection of the

network shown in Fig. 6;

Fig. 8 is a diagram showing the configuration of a

network provided by a fourth embodiment of the present

invention;

Fig. 9 is a diagram showing a DCP connection system of the network shown in Fig. 8;

Fig. 10 is a diagram showing a DCW connection system of the network shown in Fig. 8;

Fig. 11 is a diagram showing the configuration of a transmission apparatus provided by an embodiment of the present invention;

Fig. 12 is a diagram showing the configuration of a BLSR switching control unit employed in the transmission apparatus shown in Fig. 11;

Fig. 13 is a diagram showing classification of cross-connect categories;

Fig. 14 is a diagram showing a technique to create a table for a broadcasting type;

Fig. 15 is a diagram showing a technique to create a table for a broadcasting type;

Fig. 16 is a diagram showing a technique to create a table for a broadcasting type;

Fig. 17 is a diagram showing a technique to create a table for a broadcasting type;

Fig. 18 is diagrams each showing a setting miss;

Fig. 19 is a diagram showing normal add and drop operations or a DTW implementation of connection;

Fig. 20 is a diagram showing a DCP one-side-end implementation of connection;

Fig. 21 is a diagram showing a DCW one-side-end implementation of connection;

Fig. 22 is a diagram showing a DTP one-side-end implementation of connection;

Fig. 23 is a diagram showing a DCP both-side-end implementation of connection;

Fig. 24 is a diagram showing a DCW both-side-end implementation of connection;

Fig. 25 is a diagram showing an implementation of connection with a broadcasting type of a DCx one-side-end;

Fig. 26 is a diagram showing an implementation of connection with a broadcasting type of DCx both-side-ends;

Fig. 27 is a diagram showing a typical determination of the implementation of connection;

Fig. 28 is a diagram showing a topology table used in the BLSR switching control unit shown in Fig. 12;

Fig. 29 is a diagram showing the configuration of a squelch table used in the BLSR switching control unit shown in Fig. 12;

Fig. 30 is a diagram showing a typical squelch

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table for a normal/DTW connection;

Fig. 31 is a diagram showing a typical squelch table for a DCP one-side-end connection;

Fig. 32A is a diagram showing an event of a failure in a DCP one-side-end connection;

Fig. 32B is a diagram showing an event of a failure in a DCP one-side-end connection;

Fig. 32C is a diagram showing an event of a failure in a DCP one-side-end connection;

Fig. 33 is a diagram showing a typical squelch table for a DCW one-side-end connection;

Fig. 34 is a diagram showing a typical squelch table for a DCP both-side-end connection;

Fig. 35 is a diagram showing a typical squelch table for a DCW both-side-end connection;

Fig. 36 is a diagram showing a typical squelch table for a DTP connection;

Fig. 37A is a diagram showing an event of a failure in a DTP connection;

Fig. 37B is a diagram showing an event of a failure in a DTP connection;

Fig. 37C is a diagram showing an event of a failure in a DTP connection;

Fig. 38 is a diagram showing a RIP table used in

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the BLSR switching control unit shown in Fig. 12;

Fig. 39 is a diagram showing a typical RIP table for a normal/DTW connection;

Fig. 40 is a diagram showing a typical RIP table for a DCP one-side-end connection;

Fig. 41 is a diagram showing a typical RIP table for a DCW one-side-end connection;

Fig. 42 is a diagram showing a typical RIP table for a DCP both-side-end connection;

Fig. 43 is a diagram showing a typical RIP table for a DCW both-side-end connection;

Fig. 44 is a diagram showing a typical RIP table for a DTP connection;

Fig. 45 is a diagram showing a definition of a line;

Fig. 46 is a diagram showing a definition of a line range;

Fig. 47 is a diagram showing a technique to identify a place of occurrence of a failure;

Fig. 48 is a diagram showing a technique to determine an east-side N position;

Fig. 49 is a diagram showing a technique to determine an east-side R position;

Fig. 50 is a diagram showing a technique to

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determine a west-side N position;

Fig. 51 is a diagram showing a technique to determine a west-side R position;

Fig. 52A is a diagram showing a case of no occurrence of a failure between primary and secondary nodes for a DCP connection;

Fig. 52B is a diagram showing a case of occurrence of a failure between primary and secondary nodes for a DCP connection;

Fig. 53A is a diagram showing signal flows in a case of no occurrence of a failure between primary secondary nodes;

Fig. 53B is a diagram showing signal flows in a case of occurrence of a failure between primary secondary nodes;

Fig. 54 is a flowchart of classification of cross-connect information;

Fig. 55 is a diagram showing the structure of transmitted data;

Fig. 56 is a diagram showing a sequence to construct a table;

Fig. 57 is a diagram showing a sequence chart to construct a table;

Fig. 58 shows a flowchart representing construction

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of a table for an east-end station;

Fig. 59 shows a flowchart representing construction of a table for an intermediate station;

Fig. 60 shows a flowchart representing construction of a table for a through station;

Fig. 61 shows a flowchart representing construction of a table for a west-end station;

Fig. 62 shows a flowchart representing creation of a squelch table;

Fig. 63 shows a flowchart representing creation of a RIP table;

Fig. 64 shows a flowchart to identify the location of occurrence of a failure;

Fig. 65 shows a flowchart representing a switching operation carried out in the event of a failure;

Fig. 66A is a diagram showing typical reconstruction of a table;

Fig. 66B is a diagram showing typical reconstruction of a table;

Fig. 66C is a diagram showing typical reconstruction of a table;

Fig. 66D is a diagram showing typical reconstruction of a table; and

Fig. 67 shows a flowchart representing

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reconstruction of tables.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Before describing preferred embodiments of the present invention, the principle of the present invention is explained. Fig. 1 is a diagram showing the principle of the present invention. A transmission apparatus shown in the figure is a communication apparatus such as a BLSR multiplexing apparatus that has a function to switch a transmission line having a redundant configuration comprising a working line 2#W and a protection line 2#P from the working line to the protection line in the event of a transmission-line failure on the working line. As shown in Fig. 1, the transmission apparatus comprises a cross-connect-classifying means 4, a communication means 6, a connection-implementation-classifying means 8, a table 10, a failure-reporting means 12, a failure-occurrence-location-identifying means 14 and a switching control means 16. The cross-connect-classifying means 4 inputs cross-connect information from an external source and classifies the information into cross-connect categories. The cross-connect information includes a signal direction and information requesting a station employing this transmission apparatus to carry out one of

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the following pieces of processing:

addition of a signal to either the working line or the protection line;

addition of a signal to both the working line and the protection line;

dropping of a signal from either the working line or the protection line;

dropping of a signal from both the working line and the protection line;

passing-through of a signal; and

dropping of a signal from either the working line or the protection line and then relaying the signal to either the working line or the protection line.

For example, the cross-connect information is classified by putting:

the dropping of a signal from either the working line or the protection line and the addition of a signal to both the working line and the protection line in a category of addition of a signal to the working line;

the dropping of a signal from both the working line and the protection line in a category of dropping of a signal from the working line; and

the dropping of a signal from either the working line or the protection line and then relaying the signal

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to either the working line or the protection line in a category of dropping of a signal from the working line.

The communication means 6 gathers the cross-connect category of a signal-adding or signal-dropping transmission apparatus and node information for each channel in an order of the direction of a signal flowing through the channel or a direction opposite to the flowing direction in accordance with the direction of the signal. The connection-implementation-classifying means 8 classifies a variety of implementations of connection such as DCP, DCW and DTP connections into appropriate connection categories in accordance with the cross-connect category of the transmission apparatus employed in this station and the cross-connect categories of other transmission apparatuses gathered in the signal direction to create the table 10 for switching the line. The failure-reporting means 12 transmits information on a failure including node information of this station in the event of a failure on a transmission line between this station and an adjacent station. The failure-occurrence-location-identifying means 14 identifies the location of occurrence of a failure from information on the failure. The switching control means 16 executes control to switch the line based on a location of occurrence of a failure

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and the table 10. In this way, it is possible to execute

switching control according to the implementation of

connection in the event of a failure.

Fig. 2 is a diagram showing the configuration of a

network provided by a first embodiment of the present

invention. As shown in the figure, the network is a 1-

ring network 19, which comprises a plurality of BLSR

multiplexing apparatuses, for example, 8 BLSR

multiplexing apparatuses 20#i where i = 1 to 8. The BLSR

multiplexing apparatus 20#i is referred to hereafter

simply as a transmission apparatus. Any adjacent two of

the BLSR multiplexing apparatuses 20#i where i = 1 to 8

are connected to each other by 2 transmission lines such

as optical fibers, namely, a working line 21#W1 and a

protection line 21#P1 or 4 transmission lines such as

optical fibers, namely, the working line 21#W1, a working

line 21#W2, the protection line 21#P1 and a protection

line 21#P2. It should be noted that, while the ring

network 19 shown in Fig. 2 uses 4 transmission lines for

connecting any adjacent two of the BLSR multiplexing

apparatuses 20#i where i = 1 to 8 to each other, the

transmission lines represent a logical connection and

thus not implemented as separated physical transmission

media. In the case of a 2-F BLSR multiplexing apparatus,

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only 2 transmission lines are used. One of the transmission lines is shared as the working line 21#W1 and the protection line 21#P1 while the other transmission line is shared as the working line 21#W2 and the protection line 21#P2. In the ring network shown in Fig. 2, the working lines 21#W1 and 21#W2 are each represented by a solid line whereas the protection lines 21#P1 and 21#P2 are each represented by a dashed line.

Fig. 3 is a diagram showing a normal connection in the network configuration shown in Fig. 2. To be more specific, Fig. 3 shows a normal implementation of connection of adding and/or dropping a signal by the transmission apparatuses 20#2 and 20#7 in the network configuration shown in Fig. 2. If the transmission apparatus 20#2 functions as a multiplexing apparatus adding a signal to a transmission line, the transmission apparatus 20#7 functions as a terminal dropping the signal from the transmission line. If the transmission apparatus 20#7 functions as a multiplexing apparatus adding a signal to a transmission line, on the other hand, the transmission apparatus 20#2 functions as a terminal dropping the signal from the transmission line. For example, in the normal connection, a channel signal added by the multiplexing apparatus 20#2 is transmitted through

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a working line 21#W2, the transmission apparatus 20#1, a

working line 21#W2, the transmission apparatus 20#8 and a

working line 21#W2 to the terminal 20#7, which drops the

signal. On the other hand, a channel signal added by the

multiplexing apparatus 20#7 is transmitted through a

working line 21#W1, the transmission apparatus 20#8, a

working line 21#W1, the transmission apparatus 20#1 and a

working line 21#W1 to the terminal 20#2, which drops the

signal. In the event of a failure on a working line 21#W1

or 21#W2, the transmission is switched from the working

line 21#W1 or 21#W2 to a protection line 21#P1 or 21#P2

for a transmission in a direction opposite to the

transmission through the working line 21#W1 or 21#W2. If

the transmission apparatuses 20#2 and 20#7 cannot be

connected to each other by all means, they are subjected

to a squelching operation.

Fig. 4 is a diagram showing the configuration of a

network provided by a second embodiment of the present

invention. As shown in the figure, the network is a 2-

ring network, which consists of two ring networks 23#1

and 23#2. The ring network 23#1 comprises a plurality of

BLSR multiplexing apparatuses, for example, 8

transmission apparatuses 22#1i where i = 1 to 8. Likewise,

the ring network 23#2 comprises a plurality of BLSR

multiplexing apparatuses, for example, 8 transmission

apparatuses 22#2i where i = 1 to 8. The ring networks

23#1 and 23#2 are connected to each other by transmission

lines linking the transmission apparatus 22#17 of the

ring network 23#1 to the transmission apparatus 22#22 of

the ring network 23#2.

Fig. 5 is a diagram showing a DTW connection of the

configuration of the network shown in Fig. 4. To be more

specific, Fig. 5 shows a DTW implementation of connection

of adding and/or dropping a signal between the terminal

node 22#12 of the ring network 23#1 and the terminal node

22#28 of the ring network 23#2 in the configuration of

the network shown in Fig. 4. In the DTW connection, the

terminal node 22#12 adds a channel signal to a working

line 21#W1 and a working line 21#W2 in a direction

opposite to a working line 21#W1. The channel signal

added to the working line 21#W1 is transmitted through

the transmission apparatus 22#11, a working line 21#W1,

the transmission apparatus 22#18 and a working line 21#W1

to the secondary node 22#17, which drops the signal to

the network 23#2. The channel signal dropped by the

secondary node 22#17 is added by the secondary node 22#22

of the network 23#2 to a working line 21#W1 and

transmitted to the terminal node 22#28 through the

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transmission apparatus 22#21 and a working line 21#W1.

On the other hand, the channel signal added to the working line 21#W2 is transmitted through the transmission apparatus 22#13, a working line 21#W2, the transmission apparatus 22#14, a working line 21#W2, the transmission apparatus 22#15 and a working line 21#W2 to the secondary node 22#16, which drops the signal to the network 23#2. The channel signal dropped by the secondary node 22#16 is added by the secondary node 22#23 of the network 23#2 to a working line 21#W2 and transmitted to the terminal node 22#28 through the transmission apparatus 22#24, a working line 21#W2, the transmission apparatus 22#25, a working line 21#W2, the transmission apparatus 22#26, and a working line 21#W2. The terminal node 22#28 selects the channel signal received from the transmission apparatus 22#21 or 22#27 by using a PSW (path switch) and finally drops the selected one.

A channel signal added by the terminal node 22#28 to working lines 21#W1 and 21#W2 are transmitted to paths in opposite directions to the terminal node 22#12, which finally drops the signal.

Fig. 6 is a diagram showing the configuration of a network provided by a third embodiment of the present invention. As shown in the figure, the network is a 2-

ring network, which consists of two ring networks 25#1

and 25#2. The ring network 25#1 comprises a plurality of

BLSR multiplexing apparatuses, for example, 8

transmission apparatuses 24#1i where i = 1 to 8. Likewise,

the ring network 25#2 comprises a plurality of BLSR

multiplexing apparatuses, for example, 8 transmission

apparatuses 24#2i where i = 1 to 8. The ring networks

25#1 and 25#2 are connected to each other by working

lines linking the transmission apparatus 24#17 of the

ring network 25#1 to the transmission apparatus 24#22 of

the ring network 25#2 and protection lines linking the

transmission apparatus 24#16 of the ring network 25#1 to

the transmission apparatus 24#23 of the ring network 25#2.

Fig. 7 is a diagram showing a DTP connection of the

configuration of the network shown in Fig. 6. To be more

specific, Fig. 7 shows a DTP implementation of connection

of adding and/or dropping a signal between the terminal

node 24#12 of the ring network 25#1 and the terminal node

24#28 of the ring network 25#2 in the configuration of

the network shown in Fig. 6. In the DTP connection, the

terminal node 26#12 adds a channel signal to a working

line 21#W2 and a protection line 21#P2. The channel

signal added to the working line 21#W1 is transmitted

through the transmission apparatus 24#11, a working line

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21#W1, the transmission apparatus 24#18 and a working

line 21#W1 to the primary node 24#17, which drops the

signal to the network 25#2. On the other hand, the

channel signal added to the protection line 21#P2 is

transmitted through the transmission apparatus 24#13, a

protection line 21#P1, the transmission apparatus 24#14,

a protection line 21#P2, the transmission apparatus 24#15

and a protection line 21#P2 to the secondary node 24#16,

which drops the signal to the network 23#2.

The signal dropped by the primary node 24#17 is

added by the primary node 24#22 of the network 23#2 to a

working line 21#W2 and transmitted to the terminal node

24#28 through the transmission apparatus 24#21 and a

working line 21#W2. On the other hand, the channel signal

dropped by the secondary node 24#16 is added by the

secondary node 24#23 of the network 23#2 to a protection

line 21#P2 and transmitted to the terminal node 24#28

through the transmission apparatus 24#24, a protection

line 21#P2, the transmission apparatus 24#25, a

protection line 21#P2, the transmission apparatus 24#26,

a protection line 21#P2, the transmission apparatus 24#27

and a protection line 21#P2. The terminal node 24#28

selects the channel signal received from a working line

21#W2 or a protection line 21#P2 by using a PSW (path

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switch) 26#28 and finally drops the selected one.

A channel signal added by the terminal node 24#28 to working and protection lines are transmitted to paths in opposite directions to the terminal node 24#12, which finally drops the signal.

Fig. 8 is a diagram showing the configuration of a network provided by a fourth embodiment of the present invention. As shown in the figure, the network is a 3-ring network, which consists of 3 ring networks 31#i where i = 1 to 3. The ring network 31#i where i = 1 to 3 comprises a plurality of BLSR multiplexing apparatuses, for example, 8 transmission apparatuses 30#ij where j = 1 to 8. The ring networks 31#1 and 31#2 are connected to each other by working lines linking the transmission apparatus 30#16 of the ring network 31#1 to the transmission apparatus 30#22 of the ring network 31#2 and protection lines linking the transmission apparatus 30#16 of the ring network 31#1 to the transmission apparatus 30#23 of the ring network 31#2. By the same token, the ring networks 31#2 and 31#3 are connected to each other by working lines linking the transmission apparatus 30#28 of the ring network 31#2 to the transmission apparatus 30#33 of the ring network 31#3 and protection lines linking the transmission apparatus 30#27 of the ring

network 31#2 to the transmission apparatus 30#34 of the ring network 31#3.

Fig. 9 is a diagram showing a DCP connection system of the configuration of the network shown in Fig. 8. To be more specific, Fig. 9 shows a DCP implementation of connection of adding and/or dropping a signal between the terminal node 30#12 of the ring network 31#1 and the terminal node 30#38 of the ring network 31#3 in the configuration shown in Fig. 8. In the DCP connection, a channel signal added by the terminal node 30#12 to a working line 21#W1 is transmitted to the primary node 30#17 through the working line 21#W1, the transmission apparatus 30#11, a working line 21#W1, the transmission apparatus 30#18 and a working line 21#W1. The primary node 30#17 uses a DCP unit 34#17 employed therein to drop the channel signal received from a working line 21#W1 to the transmission apparatus 30#22 of the ring network 31#2 through a primary circuit 21#W1, and continues the channel signal to the secondary node 30#16 through a secondary circuit 21#P1. The secondary node 30#16 drops the channel signal received from the secondary circuit 21#P1 to the secondary node 30#23 of the ring network 31#2.

The secondary node 30#23 of the ring network 31#2

receives the channel signal dropped from the secondary

node 30#16 of the ring network 31#1 and adds the signal

to a protection line 21#P1. The transmission apparatus

30#22 of the ring network 31#2 receives the channel

signal dropped by the primary node 30#17 of the ring

network 31#1 and the channel signal added by the

secondary node 30#23 to a protection line 21#P1, using an

SS (service selector) 32#22 to select either of the

channel signals to be added to a working line 21#W1. The

channel signal added to the working line 21#W1 is

transmitted to the primary node 30#28 through the

transmission apparatus 30#21 and a working line 21#W1. A

DCP unit 34#28 employed in the primary node 30#28 drops

the channel signal to the primary node 30#33 of the ring

network 31#3 and continues the signal to the secondary

node 30#27 through a protection line 21#P1. The secondary

node 30#27 drops the channel signal received from the

secondary circuit 21#P1 to the transmission apparatus

30#34 of the ring network 31#3.

The secondary node 30#34 of the ring network 31#3

receives the channel signal dropped from the secondary

node 30#27 of the ring network 31#2 and adds the signal

to a protection line 21#P1. The transmission apparatus

30#33 of the ring network 31#3 receives the channel

signal dropped by the primary node 30#28 of the ring

network 31#2 and the channel signal added by the

secondary node 30#34 to a protection line 21#P1, using an

SS (service selector) 32#33 to select either of the

channel signals to be added to a working line 21#W1. The

channel signal added to the working line 21#W1 is

transmitted to the terminal-node transmission apparatus

30#38 through the transmission apparatus 30#32, a working

line 21#W1, the transmission apparatus 30#31 and a

working line 21#W1.

The transmission apparatuses 30#17 and 30#28, which

drop as well as continue a channel signal as described

above, are each referred to as a primary node. The

transmission apparatuses 30#22 and 30#33 also drop as

well as continue a channel signal in transmissions in a

direction opposite to that of the transmission

apparatuses 30#17 and 30#28 and are thus each referred to

as a primary node as well. On the other hand, the

transmission apparatuses 30#16 and 30#27, which drop a

channel signal to another ring network, and the

transmission apparatuses 30#23 and 30#34, which add a

channel signal received from another ring network, are

each referred to as a secondary node. A ring network

having only one secondary node is referred to as a DCP

one-side-end connection network. Examples of the DCP one-side-end connection network are the ring network 31#1 having only one secondary node, namely, the transmission apparatus 30#16, and the ring network 31#3 having only one secondary node, namely, the transmission apparatus 30#34. On the other hand, a ring network having two secondary nodes is referred to as a DCP both-side-end connection network. An example of the DCP both-side-end connection network is the ring network 31#2 having two secondary nodes, namely, the transmission apparatuses 30#23 and 30#27.

Fig. 10 is a diagram showing a DCW connection system of the configuration of the network shown in Fig. 8. As shown in Fig. 10, the DCW connection is different from the DCP connection shown in Fig. 9 in that, DCW units 40#17, 40#22 and 40#33 employed in the transmission apparatuses 30#17, 30#22 and 30#33 respectively each drop a channel signal and continue the channel signal on a working line instead of a protection line and the transmission apparatuses 30#16, 30#23, 30#27 and 30#34 each add a channel signal to working lines 21#W1 and 21#W2.

A ring network having only one secondary node is referred to as a DCW one-side-end connection network.

Examples of the DCW one-side-end connection network are the ring network 31#1 having only one secondary node, namely, the transmission apparatus 30#16, and the ring network 31#3 having only one secondary node, namely, the transmission apparatus 30#34. On the other hand, a ring network having two secondary nodes is referred to as a DCW both-side-end connection network. An example of the DCW both-side-end connection network is the ring network 31#2 having two secondary nodes, namely, the transmission apparatuses 30#23 and 30#27.

As described above, it is possible to provide a variety of implementations of connection such as the normal connection, the DTW connection, the DTP, the DCP one-side-end connection, the DCP both-side-end connection, the DCW one-side-end connection and the DCW both-side-end connection. The transmission apparatus provided by an embodiment of the present invention executes switching control according to the implementation of connection for the variety of implementations of connection.

Fig. 11 is a diagram showing the configuration of a transmission apparatus 56#i provided by an embodiment of the present invention. As shown in the figure, the transmission apparatus 56#i comprises demultiplexer units 52#i1 and 52#i2, multiplexer units 54#i1 and 54#i2, a

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cross-connect unit 56#i and a BLSR switching control unit 58#i. The demultiplexer units 52#i1 and 52#i2 receive synchronized frames such as SDH and SONET from transmission lines, namely, working lines 21#W1 and 21#W2 as well as protection lines 21#P1 and 21#P2, separating each frame into an overhead and a payload. Data of channels mapped onto the payload is extracted and supplied to the BLSR switching control unit 58#i along with the overhead. The multiplexer units 54#i1 and 54#i2 multiplex data of channels received from the BLSR switching control unit 58#i with the payload of a synchronized frame, and maps an overhead received from the BLSR switching control unit 58#i onto the synchronized frame, outputting the frame to the working lines 21#W1 and 21#W2 as well as the protection lines 21#P1 and 21#P2. The cross-connect unit 56#i outputs data of channels extracted by the demultiplexer units 52#i1 and 52#i2 to signal lines for the respective channels of an output path in accordance with line setting information. The transmission apparatus 56#i also requires a demultiplexer and a multiplexer that serve as an interface with an apparatus such as a terminal in operations to add and drop a signal. It should be noted, however, that these demultiplexer and the multiplexer are

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not shown in the figure.

The BLSR switching control unit 58#i has the following functions:

1: Input cross-connect information for each channel from a user interface unit and classify the information into cross-connect categories. A time slot in a synchronized frame is assigned to a channel for a path starting at a node adding a signal and ending at a node dropping the signal.

2: Form a judgment as to whether the station employing this transmission apparatus is an east-end station, a west-end station, an intermediate station or a through station. The judgment is based on a cross-connect category. With a signal transmitted in the counterclockwise direction, typically, the reception and transmission sides are seen by each transmission apparatus 56#i as west and east sides respectively. An end station is a station for merely adding or dropping a signal. For a channel, an end station is thus a node located at an end. Speaking about an end station adding a signal and an end station dropping a signal, an end station located on the east side is referred to as an east-end station whereas an end station located on the west side is referred to as a west-end station. An

intermediate station is a node that drops as well as continues a signal or a node that adds a signal to both working and protection lines. A through station is a node that relays (or passes through) a channel signal. In the case of the middle ring network shown in Fig. 9, for example, the transmission apparatus 30#27 is the east-end station, the transmission apparatus 30#28 is an intermediate station, the transmission apparatus 30#21 is a through station, the transmission apparatus 30#22 is an intermediate station and the transmission apparatus 30#23 is a west-end station.

3: Carry out the following functions in case the station employing this transmission apparatus is an east-end station:

3-1: Insert the cross-connect category of the station employing this transmission apparatus into the overhead of the synchronized frame and transmit the frame to an adjacent node on the west side in accordance with a predetermined protocol such as a token ring protocol.

3-2: Hand over a transmission right to the adjacent node.

3-3: Store the cross-connect category of the station employing this transmission apparatus in a stack.

3-4: Store a cross-connect category received from the adjacent station in a stack.

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4: Carry out the following functions in case the station employing this transmission apparatus is a west-end station:

4-1: Accommodate information triggering collection of cross-connect categories in the overhead of the synchronized frame and transmit the frame to an adjacent node on the east side.

4-2: In case a cross-connect category is received from an east-end station, initialize a table and store the cross-connect category in a stack.

4-3: In case a cross-connect category is not received from an east-end station, store the cross-connect category in a stack.

4-4: When a transmission right is passed around from an adjacent node on a polling basis, acquire the transmission right and accommodate the cross-connect category of the station employing this transmission apparatus in the overhead of the synchronized frame before transmitting the frame to an adjacent node on the west side. Then, store the cross-connect category of the station employing this transmission apparatus in a stack.

5: Carry out the following functions in case the station employing this transmission apparatus is a through station:

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5-1: In case a cross-connect category is received from
an east-end station, initialize a table and store the
cross-connect category in a stack.

5-2: In case a cross-connect category is not received
from an east-end station, store the cross-connect
category in a stack.

5-3: Pass on a received cross-connect category to an
adjacent node on the west side.

5-4: When a transmission right is transferred from an
adjacent node on a polling basis, pass on the
transmission right to an adjacent node on the west side.

6: Carry out the following functions in case the station
employing this transmission apparatus is an intermediate
station:

6-1: In case a cross-connect category is received from
an east-end station, initialize a table and store the
cross-connect category in a stack.

6-2: In case a cross-connect category is not received
from an east-end station, store the cross-connect
category in a stack.

6-3: Pass on a received cross-connect category to an
adjacent node on the west side.

6-4: When a transmission right is passed around from an
adjacent node on a polling basis, acquire the

transmission right and accommodate the cross-connect category of the station employing this transmission apparatus in the overhead of the synchronized frame before transmitting the frame to an adjacent node on the west side. Then, store the cross-connect category of the station employing this transmission apparatus in a stack.

7: Check a cross-connect category stored in the stack for an connection-implementation error. If such an error exists, issue a warning to the user by way of the user interface unit.

8: Identify the implementation of connection from a cross-connect category stored in the stack and create a squelch table and a RIP table.

9: If a transmission-line error is detected, report information on the failure to adjacent nodes on the east and west sides.

10: If information on a failure is received, identify the implementation of connection by referring to the squelch and RIP tables and execute switching control in accordance with the connection system.

11: Drive a switch unit such as a PSW, an SS, a ring switch or a span switch employed therein in accordance with the switching system including the submarine BLSR system or the normal BLSR system.

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Fig. 12 is a diagram showing the configuration of the BLSR switching control unit 58#i employed in the transmission apparatus shown in Fig. 11. As shown in Fig. 12, the BLSR switching control unit 58#i comprises a user interface unit 70#i, a cross-connect-classifying unit 72#i, a communication unit 74#i, a connection-implementation-classifying unit 76#i, a topology table 78#i, a squelch table 80#i, a RIP table 81#i, a failure-detecting unit 82#i, a failure-reporting unit 84#i, a failure-occurrence-location-identifying unit 86#i, a switching control unit 88#i and a switch unit 90#i. The user interface unit 70#i inputs cross-connect information entered by the user and supplies the information to the cross-connect-classifying unit 72#i. Cross-connect information is typically transmitted from a central control apparatus at a remote location by way of a LAN or from an adjacent node typically as an overhead of a synchronized frame. The cross-connect information typically includes a channel number, a signal direction, namely, the east or west direction and a line type, which indicates whether the transmission line is a working or protection line for adding, dropping, passing through or adding as well as dropping a signal. Take the connection system shown in Fig. 9 as an example. In this case, for a

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channel to which the transmission apparatus 30#12 adds a

signal, the cross-connect information is given as

follows:

The cross-connect information supplied to the

transmission apparatus 30#12:

A channel number and a request for an operation of

adding a signal to a working line in the east signal

direction.

The cross-connect information supplied to the

transmission apparatus 30#11:

A channel number and a request for an operation of

passing through a signal to a working line in the east

signal direction.

The cross-connect information supplied to the

transmission apparatus 30#18:

A channel number and a request for an operation of

passing through a signal to a working line in the east

signal direction.

The cross-connect information supplied to the

transmission apparatus 30#17:

A channel number and a request for an operation of

dropping a signal from a work line in the east signal

direction as well as relaying the signal to a protection

line in the east signal direction.

The cross-connect information supplied to the transmission apparatus 30#16:

A channel number and a request for an operation of dropping a signal from a protection line in the east signal direction.

As described above, the cross-connect information supplied to the transmission apparatus 30#17 includes a channel number and a request for operations to drop a signal from a work line in the east signal direction as well as to relay the signal to a protection line in the east signal direction, indicating a DCP (Drop and Continue on Protection) connection. Since this cross-connect information entails 2 operations, namely, signal-dropping and signal-adding operations, 2 pieces of cross-connect information are supplied at separate times. That is to say, the first cross-connection information includes a channel number and a request for an operation to drop a signal from a work line in the east signal direction and the second cross-connection information includes a channel number and a request for an operation to pass through the signal to a protection line in the east signal direction. As for a west-direction channel involved in the operation of the SS 32#17 employed in the transmission apparatus 30#17 of the middle ring network

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shown in Fig. 9, two pieces of cross-connect information are also supplied at separate times. That is to say, the first cross-connection information includes a channel number and a request for an operation to add a signal from a work line in the west signal direction and the second cross-connection information includes a channel number and a request for an operation to pass through the signal to a protection line in the west signal direction. Much like the DCP connection system described above, in the DCW connection system shown in Fig. 10, 2 pieces of cross-connect information are also supplied to a primary node at separate times.

The cross-connect-classifying unit 72#i classifies cross-connect information input by the user interface unit 70#i into cross-connect categories. Fig. 13 is a diagram showing classification of cross-connect categories. As shown in Fig. 13, cross-connect information is classified into categories of Add to Working, Add to Protection, Drop from Working and Drop from Protection.

1: Add-to-Working category

The following cross-connect information is included in the category of Add to Working:

1-1: A request for an operation of adding a signal to a

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working line in the east or west direction.

1-2: A request for an operation of adding a signal to a working line in the east or west direction or passing through a signal from a protection line in the east or west direction to a working line.

1-3: A request for an operation of adding a signal to a working line in the east or west direction and passing through a signal from a protection line in the east or west direction to a working line.

1-4: A request for an operation of adding a signal to a protection line in the east or west direction and passing through a signal from a protection line in the east or west direction to a working line.

2: Add-to-Protection category

The following cross-connect information is included in the category of Add to Protection:

2-1: A request for an operation of adding a signal to a protection line in the east or west direction.

2-2: A request for an operation of adding a signal to a protection line in the east or west direction and passing through a signal from a protection line in the east or west direction to a protection line.

3: Drop-from-Working category

The following cross-connect information is included

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in the category of Drop from Working:

3-1: Dropping a signal from a working line in the east or west direction.

3-2: Dropping a signal from a working line in the east or west direction and passing through a signal from a working line in the east or west direction to a working line.

3-3: Dropping a signal from a working line in the east or west direction and passing through a signal from a working line in the east or west direction to a protection line.

4: Drop-from-Protection category

The following cross-connect information is included in the category of Drop from Protection:

4-1: Dropping a signal from a protection line in the east or west direction.

4-2: Dropping a signal from a protection line in the east or west direction and passing through a signal from a protection line in the east or west direction to a protection line.

In the case of a through station, cross-connect information is not subjected to classification due to the fact that the information is not required for creation of a squelch table 80#i and a RIP table 81#i.

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The communication unit 74#i has the following functions:

1: Determine whether the station employing this transmission apparatus is an east-end station, a west-end station, an intermediate station or a through station on the basis of the cross-connect category.

2: If the station employing this transmission apparatus is an east-end station, carry out the following functions:

2-1: Accommodate information such as the node ID and the cross-connect category of the station employing this transmission apparatus to be described later into the overhead of the synchronized frame and transmit the frame to an adjacent node on the west side in accordance with a token ring protocol.

2-2: Hand over the transmission right to the adjacent node.

3: If the station employing this transmission apparatus is a west-end station, carry out the following functions:

3-1: Accommodate information triggering start of collection of cross-connect categories and the like in the overhead of the synchronized frame and transmit the frame to an adjacent node on the east side.

3-2: When a transmission right is passed around from an

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adjacent node on a polling basis, acquire the
transmission right and accommodate the cross-connect
category of the station employing this transmission
apparatus in the overhead of the synchronized frame
before transmitting the frame to an adjacent node on the
west side.

4: If the station employing this transmission apparatus
is a west-end station, carry out the following functions:

4-1: Pass on a received cross-connect category to an
adjacent node on the west side.

4-2: When a transmission right is passed around from an
adjacent node on a polling basis, acquire the
transmission right and accommodate the cross-connect
category of the station employing this transmission
apparatus in the overhead of the synchronized frame
before transmitting the frame to an adjacent node on the
west side.

5: If the station employing this transmission apparatus
is an intermediate station, carry out the following
functions:

5-1: Pass on a received cross-connect category to an
adjacent node on the west side.

5-2: When a transmission right is passed around from an
adjacent node on a polling basis, acquire the

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transmission right and accommodate the cross-connect category of the station employing this transmission apparatus in the overhead of the synchronized frame before transmitting the frame to an adjacent node on the west side.

6: Output information such as a received cross-connect category to the connection-implementation-classifying unit 76#i.

7: When receiving information on a failure from the failure-reporting unit 84#i, insert the information (including the node ID of the station employing this transmission apparatus) into typically K1 and K2 bytes of the overhead of the synchronized frame before transmitting the frame to an adjacent node on the west side.

The connection-implementation-classifying unit 76#i has the following functions:

1: If the station employing this transmission apparatus is an east-end station, initialize a stack and store information such as the cross-connect category of the station employing this transmission apparatus at the head of the stack.

2: Store information such as the cross-connect category in a stack table.

When the communication unit 74#i receives information such as a cross-connect category from an adjacent node, the communication unit 74#i forms a judgment as to whether or not a node corresponding to the information such as a cross-connect category received this time or stored in the stack right before is a broadcasting node on the basis of a cross-connect category stored in the stack as will be described later. If the node corresponding to such information is a broadcasting node, the cross-connect category received this time is not stored, or the cross-connect category received this time is stored, overwriting the cross-connect category stored in the stack right before. A broadcasting node is a node provided on a connection system of a DCx one-side/both-side broadcasting type adopting the submarine BLSR technique. In this implementation of connection, there exists a broadcasting node dropping a signal as well as continuing the signal to a protection or working line between a primary node and a secondary node for a DCx side-end connection. This broadcasting node is thus a node for dropping a signal and broadcasting the signal to nodes such as terminals in another ring network or the like. This is because removal of information on the broadcasting node from the stack

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has nothing to do with switching control. When a

transmission right is passed around from an adjacent node

on a polling basis, information such as a cross-connect

category is stored in a stack if the station employing

this transmission apparatus is a middle or west station.

In this way, pieces of cross-connect information are

stored in the stack in an order from the east direction.

Figs. 14 to 17 are diagrams showing a technique to

create a table for a DCx both-side-end broadcasting type.

To be more specific, Figs. 14 and 15 are diagrams showing

a technique to create a table for a case in which a

signal propagating from the east direction is added. On

the other hand, Figs. 16 and 17 are diagrams showing a

technique to create a table for a case in which a signal

propagating from the west direction is added. In the

network shown in Fig. 14, nodes 100#1 and 100#7 are each

a secondary node, a node 100#3 is a through node, nodes

100#2 and 100#4 are each a primary node whereas nodes

100#5 and 100#6 are each a broadcasting node (or a

virtual secondary node). As shown in Fig. 14, the

transmission of a signal starts from the signal-adding

secondary node 100#1 and ends with 4 consecutive signal-

dropping nodes, namely, the signal-dropping primary node

100#4, the signal-dropping broadcasting node 100#5, the

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signal-dropping broadcasting node 100#6 and the signal-dropping secondary node 100#7. The first signal-dropping cross-connect category of the primary node 100#4 and the last signal-dropping cross-connect category of the secondary node 100#7 are gathered but the signal-dropping cross-connect categories of nodes between the primary node 100#4 and the secondary node 100#7 are not. That is to say, if the cross-connect category of the first node is a category of adding of a signal, a signal-dropping cross-connection category received this time such as the cross-connection category of a virtual secondary node shown in Fig. 15 is not stored in a stack provided that an immediately preceding cross-connection category such as the cross-connection category of a primary node shown in Fig. 15 is also a category of dropping of a signal.

In the network shown in Fig. 16, nodes 100#1 and 100#7 are each a secondary node, a node 100#3 is a through node, nodes 100#5 and 100#6 are each a primary node whereas nodes 100#2 and 100#4 are each a broadcasting node (or a virtual secondary node). As shown in Fig. 16, the transmission of a signal starts from the signal-adding secondary node 100#7 and ends with 4 consecutive signal-dropping nodes, namely, the signal-dropping primary node 100#5, the signal-dropping

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broadcasting node 100#4, the signal-dropping broadcasting node 100#2 and the signal-dropping secondary node 100#1. In this case, when a signal is dropped by 2 consecutive nodes, the second data is used by this station for overwriting the first one. To put it in detail, a signal-dropping cross-connect category received this time is stored, overwriting an immediately preceding signal-dropping cross-connect category. That is to say, if the cross-connect category of the first node is a category of adding of a signal, a signal-dropping cross-connection category received this time such as the cross-connection category of a virtual secondary node shown in Fig. 17 is stored in a stack, overwriting an immediately preceding cross-connection category such as the cross-connection category of a primary node shown in Fig. 17 provided that the immediately preceding cross-connection category such as the cross-connection category of the primary node shown in Fig. 17 is also a category of dropping of a signal. In this way, in the case of the both-side DCx broadcasting type, the cross-connect category of a broadcasting node is not collected. In the case of the one-side DCx broadcasting type, the node 100#2 shown in Fig. 14 and the node 100#6 shown in Fig. 16 merely disappear. Thus, the operations to store cross-connect

category for the one-side DCx broadcasting type are carried out in the same way as the both-side DCx broadcasting type.

3: Check a connection miss.

Figs. 18A to 18C are diagrams each showing a setting miss. To be more specific, Fig. 18A shows a consecutive Drop → Add case or a consecutive Add → Drop case. Fig. 18B shows consecutive Add → Add cases. Fig. 18C shows a consecutive Add → Drop → Add → Drop case or a consecutive Drop → Add → Drop → Add case. In either case, a setting miss is determined to exist and a warning of the setting miss is reported to the user by way of the user interface unit 70#i.

4: Classify implementations of connection on the basis of cross-connection categories stored in the stack.

As described above, implementations of connection include the normal connection, the DTW connection, the DCP one-side-end connection, the DCP both-side-end connection, the DCW one-side-end connection and the DCW both-side-end connection. The implementations of connection are classified as follows.

4-1: Normal Add/Drop or DTW Implementation of Connection

Fig. 19 is a diagram showing normal add and drop operations or a DTW implementation of connection. As

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shown in Fig. 19, if the cross-connection categories
stored in the stack are categories of adding a signal to
a working line and dropping a signal from a working line
or categories of dropping a signal from a working line
and adding a signal to a working line, the implementation
of connection is determined to be a normal Add/Drop or
DTW implementation of connection.

4-2: DCP One-side-end Implementation of Connection

Fig. 20 is a diagram showing a DCP one-side-end
implementation of connection. As shown in Fig. 20, if the
cross-connection categories stored in the stack are
categories of adding a signal to a protection line,
adding a signal to a working line and dropping a signal
from a working line, or categories of dropping a signal
from a protection line, dropping a signal from a working
line and adding a signal to a working line, or categories
of dropping a signal from a working line, adding a signal
to a working line and adding a signal to a protection
line, or categories of adding a signal to a working line,
dropping a signal from a working line and dropping a
signal from a protection line, the implementation of
connection is determined to be a DCP one-side-end
implementation of connection.

4-3: DCW One-side-end Implementation of Connection

Fig. 21 is a diagram showing a DCW one-side-end implementation of connection. As shown in Fig. 21, if the cross-connection categories stored in the stack are categories of adding a signal to a working line, adding a signal to a working line and dropping a signal from a working line, or categories of dropping a signal from a working line, dropping a signal from a working line and adding a signal to a working line, or categories of dropping a signal from a working line, adding a signal to a working line and adding a signal to a working line, or categories of adding a signal to a working line, dropping a signal from a working line and dropping a signal from a working line, the implementation of connection is determined to be a DCW one-side-end implementation of connection.

4-4: DTP One-side-end Implementation of Connection

Fig. 22 is a diagram showing a DTP one-side-end implementation of connection. As shown in Fig. 22, if the cross-connection categories stored in the stack are categories of dropping a signal from a protection line, adding a signal to a working line and dropping a signal from a working line, or categories of adding a signal from a protection line, dropping a signal from a working line and adding a signal to a working line, or categories

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of dropping a signal from a working line, adding a signal to a working line and dropping a signal from a protection line, or categories of adding a signal to a working line, dropping a signal from a working line and adding a signal to a protection line, the implementation of connection is determined to be a DTP one-side-end implementation of connection.

4-5: DCP Both-side-end Implementation of Connection

Fig. 23 is a diagram showing a DCP both-side-end implementation of connection. As shown in Fig. 23, if the cross-connection categories stored in the stack are categories of adding a signal to a protection line, adding a signal to a working line, dropping a signal from a working line and dropping a signal from a protection line, or categories of dropping a signal from a protection line, dropping a signal from a working line, adding a signal to a working line and adding a signal to a protection line, the implementation of connection is determined to be a DCP both-side-end implementation of connection.

4-6: DCW Both-side-end Implementation of Connection

Fig. 24 is a diagram showing a DCW both-side-end implementation of connection. As shown in Fig. 24, if the cross-connection categories stored in the stack are

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categories of adding a signal to a working line, adding a

signal to a working line, dropping a signal from a

working line and dropping a signal from a working line,

or categories of dropping a signal from a working line,

dropping a signal from a working line, adding a signal to

a working line and adding a signal to a working line, the

implementation of connection is determined to be a DCW

both-side-end implementation of connection.

4-7: DCx One-side-end Implementation of Connection

Fig. 25 is a diagram showing a DCx one-side-end

implementation of connection where the symbol x

represents P or W, which stands for a protection or

working line respectively. Fig. 25 shows a case with only

one broadcasting node. It is worth noting, however, that

2 or more broadcasting nodes may exist in some cases. For

example, a channel with the left-end node serving as a

node adding a signal to a transmission line comprises a

primary node at the left end successively followed by a

primary node, a broadcasting node and a secondary node.

On the other hand, a channel with the left-end node

serving as a node dropping a signal from a transmission

line comprises a secondary node at the left end

successively followed by a broadcasting node, a primary

node and a primary node. As shown in the figure, if the

cross-connection categories stored in the stack are categories of adding a signal to a working or protection line, dropping a signal from a working line and dropping a signal from a working line, or categories of dropping a signal from a working line, and adding a signal to a working or protection line, the implementation of connection is determined to be a DCx one-side-end implementation of connection. It should be noted that, as described before, the cross-connect category of a broadcasting node is not stored in the stack.

4-8: DCx Both-side-end Implementation of Connection

Fig. 26 is a diagram showing a DCx both-side-end implementation of connection where the symbol x represents P or W. The DCx both-side-end implementation of connection is an implementation adopted for the submarine BLSR technique. The implementation of connection shown in the figure is a DCx both-side-end connection in which there are a plurality of broadcasting nodes dropping a signal and continuing the signal to a protection or working line between a primary node and a secondary node. Fig. 26 shows a case with only one broadcasting node. It is worth noting, however, that 2 or more broadcasting nodes may exist in some cases. For example, a channel with the left-end node serving as a

node adding a signal to a transmission line comprises a secondary node at the left end successively followed by a primary node, a primary node, a broadcasting node and a secondary node. On the other hand, a channel with the left-end node serving as a node dropping a signal from a transmission line comprises a secondary node at the left end successively followed by a broadcasting node, a primary node, a primary node and a secondary node. As shown in the figure, if the cross-connection categories stored in the stack are categories of adding a signal to a working or protection line, adding a signal to a working line, dropping a signal from a working line and dropping a signal from a working line, or categories of dropping a signal from a working line, dropping a signal from a working line, adding a signal to a working line and adding a signal to a working or protection line, the implementation of connection is determined to be a DCx both-side-end implementation of connection. It should be noted that, as described before, the cross-connect category of a broadcasting node is not stored in the stack.

Fig. 27 is a diagram showing a typical determination of the implementation of connection. In a DCP connection shown in Fig. 27, a node 100#A adds a

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signal to a protection line, a node 100#B adds a signal

to a working line and a node 100#C drops a signal from a

protection line. Thus, cross-connection information

stored in the stack is categories of adding a signal to a

protection line, adding a signal to a working line and

dropping a signal from a protection line, indicating a

DCP connection.

4: Create a squelch table 80#i shown in Fig. 29 in

accordance with an identified implementation of

connection and the topology table 78#i.

Fig. 28 is a diagram showing the topology table

78#i used in the BLSR switching control unit 58#i shown

in Fig. 12. As shown in Fig. 28, the topology table 78#i

is a table showing an order of connection of NEs

connected to form a ring in a direction to the east side

starting with the node ID of the station including this

table. For example, the topology table 78#A in the A

station 100#A, contains node IDs A, D, C and B arranged

in the order in which the node IDs are enumerated. A

topology table 78#i is used typically for setting

information in the squelch table 80#i and the RIP table

81#i and identifying the location of occurrence of a

failure by conversion of a node ID of an NE into a

modified node ID representing a distance from the station

including the topology table 78#i to the NE.

Fig. 29 is a diagram showing the configuration of the squelch table 80#i used in the BLSR switching control unit 58#i shown in Fig. 12. As shown in Fig. 29, information is stored in the squelch table 80#i for each channel. The information for each channel includes information with the channel serving as a channel adding a signal to a transmission line and information with the channel serving as a channel dropping a signal from a transmission line. The information with the channel serving as a channel adding a signal to a transmission line is information for the east direction and information for the west direction. Likewise, the information with the channel serving as a channel dropping a signal from a transmission line is information for the east direction and information for the west direction. The information for the east direction is a modified node ID of a source node ID and a modified node ID of a destination node ID. Similarly, the information for the west direction is a modified node ID of a source node ID and a modified node ID of a destination node ID. As described above, the modified node ID of an NE is a distance from the station including the squelch table 80#i to the NE. To put it concretely, the modified node

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ID of an NE is the number of nodes located along the
transmission line in the east direction between the
station including the squelch table 80#i and the NE with
the station not counted. For example, the modified node
ID of the station including the squelch table 80#i itself
is 0 and the modified node ID of the adjacent station on
the east side is 1. Modified node IDs are used because,
by converting the node ID of a node involved in a
transmission-line failure and the node IDs of nodes
composing the ring network into modified node IDs, the
location of occurrence of a failure can be identified
with ease by carrying out logic processing.

Fig. 30 is a diagram showing a typical squelch
table 80#i for a normal/DTW connection. Refer to the
network shown on the upper part of Fig. 30. In channels
along paths indicated by thick lines, signals are added
and dropped between terminal nodes 100#2 and 100#4. In
actuality, the ring network shown in Fig. 30 comprises 8
nodes. However, only 6 nodes 100#i where i = 1 to 6 are
shown in the figure and the remaining two nodes are
omitted. In the figure, the left side is the east side
while the right side is the west side. This assignment of
the east and west sides also holds true of Figs. 31 to 44.
In Fig. 30, in a squelch table 80#2 on the west side of

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the terminal node 100#2, a modified node ID of 0 of the terminal node 100#2 and a modified node ID of 6 of the terminal node 100#4 are set. By the same token, a modified node ID of 1 of the terminal node 100#2 and a modified node ID of 7 of the terminal node 100#4 are set in a squelch table 80#3 on the east side of the node 100#3. Likewise, a modified node ID of 4 of the terminal node 100#2 and a modified node ID of 0 of the terminal node 100#4 are set and in a squelch table 80#4 on the east side of the terminal node 100#4. It should be noted that numbers enclosed in parentheses in the squelch tables 80#2, 80#3 and 80#4 shown in Fig. 30, that is, the numbers (2) and (4), are the original node IDs of the terminal node 100#2 and the terminal node 100#4 respectively.

Fig. 31 is a diagram showing a typical squelch table 80#i for a DCP one-side-end connection. In a network shown in Fig. 31, nodes 100#2, 100#3, 100#4, 100#5 and 100#6 serve as an east-end station, a through station, an intermediate station, a through station and a west-end station respectively. Information such as a cross-connect category is stored in the stack in the following order: information for the east-end station 100#2, information for the intermediate node 100#4 and

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information for the west-end station 100#6. Each channel
is assigned to a path indicated by a thick solid line and
a thick dashed line. The thick solid lines each represent
a working line between the east-end station 100#2 and the
intermediate node 100#4 whereas the thick dashed lines
each represent a protection line between the intermediate
node 100#4 and the west-end station 100#6. Thus, the
working lines allocated to the channel pass through the
east-end station 100#2, the through node 100#3 and the
intermediate node 100#4. In a squelch table 80#2 on the
west side of the east-end station 100#2, a squelch table
80#3 on the east side of the through node 100#3 and a
squelch table 80#4 on the east side of the intermediate
node 100#4, modified node IDs for a node ID of (2) of the
primary node 100#2 and a node ID of (6) of the terminal
node 100#4 are set.

Figs. 32A to 32C are each a diagram showing an
event of a failure in a DCP one-side-end connection. To
be more specific, Fig. 32A shows a case in which a
transmission-line failure occurs on working lines between
a terminal node 100#2 and a through node 100#3 so that
communications through working lines between the terminal
node 100#2 and a primary node 100#4 become impossible. In
order to rescue the ring network from this failure, the

terminal node 100#2 and the through node 100#3 each provide a bridge between the working lines and protection lines. In addition, a secondary node 100#6 switches transmission of signals from working lines to protection lines. As a result, a communication between the terminal node 100#2 and the primary node 100#4 becomes possible. Thus, a squelching operation is not necessary in this case. In addition, since modified node IDs of the terminal node 100#2 and the secondary node 100#6 are set in the squelch table 80#i and the terminal node 100#2 and the secondary node 100#6 are connected to each other, a squelching operation is not carried out.

Fig. 32B shows a case in which a transmission-line failure occurs on working lines between the terminal node 100#2 and the though node 100#3 and, in addition, a transmission-line failure also occurs on the transmission lines between the secondary node 100#6 and a node on the west side thereof. As a result, communications between the primary node 100#4 and the terminal node 100#2 as well as communications between the secondary node 100#6 and the terminal node 100#2 are disabled, making it impossible to rescue the ring network. Since modified node IDs of the secondary node 100#6 and the terminal node 100#2 are set in the squelch table 80#i, however,

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they are squelched.

Fig. 32C shows a case in which a transmission-line failure occurs on working lines between the terminal node 100#2 and the through node 100#3 and, in addition, a failure also occurs on the transmission lines between a through node 100#5 and the secondary node 100#6. As a result, communications between the primary node 100#4 and the terminal node 100#2 as well as communications between the secondary node 100#6 and the primary node 100#4 are disabled. In order to rescue the ring network from these failures, the terminal node 100#2 provides a bridge between the working lines and protection lines. In addition, the secondary node 100#6 switches transmission of signals from working lines to protection lines, dropping and adding signals from and to the protection lines. As a result, a communication between the terminal node 100#2 and the secondary node 100#6 becomes possible.

At that time, the connection between the primary node 100#4 and the terminal node 100#2 may have been cataloged in a squelch table. In this case, since the primary node 100#4 and the terminal node 100#2 cannot be connected to each other, a squelching operation is inevitably carried out. Since the connection between the secondary node 100#6 and the terminal node 100#2 is

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already cataloged in the squelch table 80#i and, in addition, the secondary node 100#6 and the terminal node 100#2 can be connected to each other, however, no squelching operation is carried out. Thus, in the case of a DCP one-side-end connection, cataloging of the modified node IDs of the secondary node 100#6 and the terminal node 100#2 in the squelch table 80#i is proper. That is to say, in the case of a DCP one-side-end connection, the node IDs of the east-end station and the west-end station are set in the squelch table 80#i.

Fig. 33 is a diagram showing a typical squelch table 80#i for a DCW one-side-end connection. In a network shown in Fig. 33, nodes 100#2, 100#3, 100#4, 100#5 and 100#6 serve as an east-end station, a through station, an intermediate station, a through station and a west-end station respectively. Cross-connect categories are stored in the stack in the following order: a category for the east-end station 100#2, a category for the intermediate node 100#4 and a category for the west-end station 100#6. Each channel is assigned to a path indicated by a thick solid line. The thick solid lines each represent a working line between the terminal nodes 100#2 and 100#6. Thus, working lines pass through the east-end station 100#2 to the west-end station 100#6. In

each of a squelch table 80#2 on the west side of the east-end station 100#2, a squelch table 80#3 on the east side of the through node 100#3, a squelch table 80#4 on the east side of the intermediate node 100#4, a squelch table 80#5 on the east side of the through node 100#5 and a squelch table 80#6 on the east side of the west-end station 100#6, a modified node ID of the east-end station 100#2 and a modified node ID of the west-end station 100#6 are set for the same reasons as the DCP one-side-end connection.

Fig. 34 is a diagram showing a typical squelch table 80#i for a DCP both-side-end connection. In a network shown in Fig. 34, nodes 100#1, 100#2, 100#3, 100#4, 100#5 and 100#6 serve as an east-end station, an intermediate station, a through station, an intermediate station, a through station and a west-end station respectively. Cross-connect categories are stored in the stack in the following order: a category for the east-end station 100#1, a category for the intermediate node 100#2, a category for the intermediate node 100#4 and a category for the west-end station 100#6. Each channel is assigned to a path indicated by a thick solid line and a dashed line. Thus, working lines pass through the intermediate node 100#2, the through 100#3 and the intermediate

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station 100#4. In each of a squelch table 80#2 on the west side of the intermediate node 100#2, a squelch table 80#3 on the east side of the through node 100#3 and a squelch table 80#4 on the east side of the intermediate node 100#4, a modified node ID of the east-end station 100#1 and a modified node ID of the west-end station 100#6 are set for the following reason. As shown in Fig. 9, if the secondary nodes 30#23 and 30#27 can be connected to each other, the terminal nodes 30#12 and 30#38 can be connected to each other through protection lines in the ring network 31#2.

Fig. 35 is a diagram showing a typical squelch table for a DCW both-side-end connection. In a network shown in Fig. 35, nodes 100#1, 100#2, 100#3, 100#4, 100#5 and 100#6 serve as an east-end station, an intermediate station, a through station, an intermediate station, a through station and a west-end station respectively. Each channel is assigned to a path indicated by a thick solid line. Thus, working lines pass through the east-end station 100#1 to the west-end station 100#6. In each of a squelch table 80#1 on the west side of the east-end station 100#1, a squelch table 80#2 on the east side of the intermediate node 100#2, a squelch table 80#3 on the east side of the through node 100#3 and a squelch table

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80#4 on the east side of the intermediate node 100#4, a

modified node ID of the secondary node 100#1 and a

modified node ID of the secondary node 100#6 are set for

the following reason. As shown in Fig. 10, if the

secondary nodes 30#23 and 30#27 can be connected to each

other, the terminal nodes 30#12 and 30#38 are capable of

communicating with each other through protection lines in

the ring network 31#2 as is the case with the DCP both-

side-end connection.

Fig. 36 is a diagram showing a typical squelch

table 80#i for a DTP connection. In a network shown in

Fig. 36, nodes 100#2, 100#3, 100#4, 100#5 and 100#6 serve

as an east-end station, a through station, an

intermediate station, a through station and a west-end

station respectively. Each channel is assigned to a path

indicated by a thick solid line and a dashed line. Thus,

working lines pass through the east-end station 100#2,

the through node100#3 and the intermediate node 100#4. In

each of a squelch table 80#2 on the west side of the

east-end station 100#2, a squelch table 80#3 on the east

side of the through node 100#3 and a squelch table 80#4

on the east side of the intermediate node 100#4, a

modified node ID of the primary node 100#4 and a modified

node ID of the secondary node 100#6 are set for the

following reason.

Figs. 37A to 37C are each a diagram showing an event of a failure in a DTP connection. To be more specific, Fig. 37A shows a case in which a transmission-line failure occurs on working lines between a primary node 100#2 and a through node 100#3 so that the primary node 100#2 and a terminal node 100#4 are not capable of communicating with each other through the working lines. In order to rescue the ring network from the failure, the same switching operations as that for the failure shown in Fig. 32A are carried out. As a result, a communication between the primary node 100#2 and the terminal node 100#4 becomes possible. Thus, a squelching operation is not necessary in this case. In addition, since modified node IDs of the terminal node 100#4 and the secondary 100#6 are set in the squelch table 80#i and the terminal node 100#4 and the secondary node 100#6 are connected to each other, a squelching operation is not carried out.

Fig. 37B shows a case in which a transmission-line failure occurs on working lines between the primary node 100#2 and the through node 100#3 and, in addition, a failure also occurs on the transmission lines between the secondary node 100#6 and a node on the west side thereof. As a result, communications between the node 100#i, where

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i = 4 and 6, and the primary node 100#2 are disabled.

In order to rescue the ring network from the failures, the through node 100#3 provides a bridge between work lines and protection lines. In addition, the terminal node 100#4 passes through a signal to or from a protection line whereas the secondary node 100#6 adds a signal to a protection line or drops a signal from a protection line. As a result, communications between the terminal node 100#4 and the secondary node 100#6 become possible. At that time, the connection between the terminal node 100#4 and the primary node 100#2 may have been cataloged in a squelch table. In this case, since the terminal node 100#4 and the primary node 100#2 cannot be connected to each other, a squelching operation is inevitably required. In addition, since modified node IDs of the secondary node 100#6 and the primary node 100#2 are set in the squelch table 80#i, however, a squelching operation is inevitably carried out. Since the connection between the secondary node 100#6 and the terminal node 100#4 is already cataloged in the squelch table 80#i and, in addition, the secondary node 100#6 and the terminal node 100#4 can be connected to each other, however, no squelching operation is carried out.

Fig. 37C shows a case in which a transmission-line

failure occurs on working lines between the primary node 100#2 and the through node 100#3 and, in addition, a failure also occurs on the transmission lines between a node 100#5 and the secondary node 100#6. As a result, communications between the terminal node 100#4 and the primary node 100#2 as well as communications between the secondary node 100#6 and the terminal node 100#4 are disabled, making it impossible to rescue the ring network from the failures.

At that time, since the modified IDs of the terminal node 100#4 and the secondary node 100#6 have been cataloged in a squelch table and, in addition, the terminal node 100#4 and the secondary node 100#6 cannot be connected to each other, a squelching operation is inevitably carried out. Thus, since the modified node IDs according to the implementation of connection are set in the squelch table 80#i as such, a proper switching operation can be carried out and no squelching operation is carried out in case the ring network can be rescued from failures.

5: Create a RIP table 81#i based on a classified implementation of connection and the topology table 78#i.

Fig. 38 is a diagram showing a RIP table 81#i used in the BLSR switching control unit 58#i shown in Fig. 12.

As shown in Fig. 38, information is stored in the RIP

table 81#i for each channel. The information for each

channel includes information with the channel serving as

a channel adding a signal to a transmission line and

information with the channel serving as a channel

dropping a signal from a transmission line. The

information with the channel serving as a channel adding

a signal to a transmission line is information for the

east direction and information for the west direction.

Likewise, the information with the channel serving as a

channel dropping a signal from a transmission line is

information for the east direction and information for

the west direction. The information for the east

direction is modified node IDs and pieces of path

information. Similarly, the information for the west

direction is modified node IDs and pieces of path

information. Path information is information for

identifying an implementation of connection such as a DCP,

DCW or DTW connection. For every channel, a RIP table

81#i is created on the east side of each node, which adds

and/or drops a signal to and/or from a transmission line.

By the same token, for every channel, a RIP table 81#i is

created on the west side of each node, which adds and/or

drops a signal to and/or from a transmission line. To put

it in detail, the modified node IDs and pieces of path

information in the information for the east direction are

stored in 4 columns, which are assigned to a secondary

node, a primary node/a terminal node, a primary node/a

terminal node and a secondary node respectively. By the

same token, the modified node IDs and pieces of path

information in the information for the west direction are

stored in 4 columns, which are assigned to a secondary

node, a primary node/a terminal node, a primary node/a

terminal node and a secondary node respectively. The 4

columns are arranged from the left to the right in the

order in which the nodes are arranged from the east side

to the west side. That is to say, the 4 columns are

arranged from the left to the right in the order in which

pieces of cross-connect information are stored in a stack.

It should be noted that the 4 columns may not necessarily

all be used. In other words, the usage of the columns is

determined by the implementation of connection. In the

case of the both-side-end DCP connection and the both-

side-end DCW connection, for example, all the 4 columns

are used whereas, in the case of the one-side-end DCP

connection and the one-side-end DCW connection, only 3

columns are used. In the case of the normal connection

and the DTW connection, on the other hand, only 2 columns

are used. Unused columns are each treated as an empty

column showing a special value for indicating that no

data is set in the column. As will be indicated later,

the special value is represented typically by a hyphen '-

'.

As path information, the symbol W denoting a

working line, the symbol P denoting a protection line or

the special value for indicating that no data is set is

described in the column of the secondary node, and the

symbol DCx (representing DCP/DCW), the symbol DT or the

special value is set in the column of the primary node or

the terminal node. In the case of the DCP both-side-end

connection, for example, the 4 columns contain the

following 4 pieces of path information: P, DCx, DCx and P

respectively. In the case of the DCP both-side-end

connection, on the other hand, the 4 columns contain the

following 4 pieces of path information: the special value,

the special value, DCx and W respectively. In this way,

the implementation of connection can be identified from

the pieces of path information. It should be noted that,

in the case of an implementation of connection with a DCx

broadcasting type, no information on broadcasting nodes

is set in the RIP table 81#i.

Fig. 39 is a diagram showing a typical RIP table

81#i for a normal/DTW connection. The implementation of connection is the same as that shown in Fig. 30. As shown in Fig. 39, for channel CH1 indicated by a thick line, RIP tables 81#2 and 81#4 are set on the west side of a node 100#2 and the east side of a node 100#4 respectively. In the case of channel CH1, for example, the data of the east side in the RIP table 81#4 includes modified node IDs of (a special value, 2 (2), 0 (4) and a special value) as well as pieces of path information of (a special value, a special value, a special value and a special value). The numbers enclosed in parentheses are each a node ID.

Fig. 40 is a diagram showing a typical RIP table 81#i for a DCP one-side-end connection. The implementation of connection is the same as that shown in Fig. 31. As shown in Fig. 40, for channel CH1 indicated by a thick line and a dashed line, RIP tables 81#2 and 81#4 are set on the west side of a node 100#2 and the east side of a node 100#4 respectively. In the case of channel CH1, for example, the data of the east side in the RIP table 81#6 includes modified node IDs of (a special value, 4 (2), 2 (4) and 0 (6)) as well as pieces of path information of (a special value, a special value, DCx and P).

Fig. 41 is a diagram showing a typical RIP table 81# I for a DCW one-side-end connection. The implementation of connection is the same as that shown in Fig. 33. As shown in Fig. 41, for channel CH1 indicated by a thick line, RIP tables 81#2, 81#4 and 81#6 are set on the west side of a node 100#2, the east side of a node 100#4 and the east side of a node 100#6 respectively. In the case of channel CH1, for example, the data of the east side in the RIP table 81#6 includes modified node IDs of (a special value, 4 (2), 2 (4) and 0 (6)) as well as pieces of path information of (a special value, a special value, DCx and W).

Fig. 42 is a diagram showing a typical RIP table 81#i for a DCP both-side-end connection. The implementation of connection is the same as that shown in Fig. 34. As shown in Fig. 42, for channel CH1 indicated by a thick line and a dashed line, RIP tables 81#1, 81#2, 81#4 and 81#6 are set on the west side of a node 100#1, the west side of a node 100#2, the east side of a node 100#4 and the east side of a node 100#6 respectively. In the case of channel CH1, for example, the data of the east side in the RIP table 81#6 includes modified node IDs of (5 (1), 4 (2), 2 (4) and 0 (6)) as well as pieces of path information of (P, DCx, DCx and P).

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Fig. 43 is a diagram showing a typical RIP table 81#i for a DCW both-side-end connection. The implementation of connection is the same as that shown in Fig. 35. As shown in Fig. 43, for channel CH1 indicated by a thick line, RIP tables 81#1, 81#2, 81#4 and 81#6 are set on the west side of a node 100#1, the west side of a node 100#2, the east side of a node 100#4 and the east side of a node 100#6 respectively. In the case of channel CH1, for example, the data of the east side in the RIP table 81#6 includes modified node IDs of (5 (1), 4 (2), 2 (4) and 0 (6)) as well as pieces of path information of (W, DCx, DCx and W).

Fig. 44 is a diagram showing a typical RIP table 81#i for a DTP connection. The implementation of connection is the same as that shown in Fig. 36. As shown in Fig. 44, for channel CH1 indicated by a thick line and a dashed line, RIP tables 81#2, 81#4 and 81#6 are set on the west side of a node 100#2, the east side of a node 100#4 and the east side of a node 100#6 respectively. In the case of channel CH1, for example, the data of the east side in the RIP table 81#6 includes modified node IDs of (a special value, 4 (2), 2 (4) and 0 (6)) as well as pieces of path information of (a special value, a special value, DT and P).

The failure-detecting unit 82#i employed in the BLSR switching control unit 58#i shown in Fig. 12 senses abnormalities such as a signal interruption and a signal-level deterioration in order to detect a failure on a transmission line between the station employing this failure-detecting unit and an adjacent node, outputting information on the failure to the failure-reporting unit 84#i. The failure-reporting unit 84#i reports the information on the failure to the communication unit 74#i and the failure-occurrence-location-identifying unit 86#i. The information on a failure includes information on whether a transmission line generating a failure propagates a signal in the east or west direction.

The failure-occurrence-location-identifying unit 86#i modifies a node ID included in information on a failure received from the failure-reporting unit 84#i or the communication unit 74#i. The modified node ID is compared with each modified node ID cataloged in the squelch table 80#i and the RIP table 81#i to form a True/False judgment for each cataloged modified node ID. The location of occurrence of a failure is determined from the result of the judgment as will be described later.

Fig. 45 is a diagram showing a definition of a line.

In the definition shown in Fig. 45, if a squelch table 80#i or a RIP table 81#i exists on the west side as shown by a white circle in the upper drawing, the line in the east direction is represented by the symbol N and the line in the west direction is represented by the symbol R. If a squelch table 80#i or a RIP table 81#i exists on the east side as shown by a white circle in the lower drawing, on the other hand, the line in the west direction is represented by the symbol N and the line in the east direction is represented by the symbol R.

Fig. 46 is a diagram showing a typical definition of a line range. Fig. 46 shows a definition for DCP/DCW both-side-end connections. Nodes 100#10 and 100#7 are each a secondary node whereas nodes 100#15 and 100#1 are primary/terminal nodes. A transmission line between the nodes 100#15 and 100#1 is in a currently used range (or a working line). A transmission line between the nodes 100#15 and 100#10 is a spare (or protection) line. Likewise, a transmission line between the nodes 100#7 and 100#1 is also a spare (or protection) line. A transmission line between the nodes 100#10 and 100#7 is another line. As shown in Fig. 46, for a channel assigned to the currently used range, RIP tables 81#10, 81#15, 81#1 and 81#7 exist on the west side of the node 100#10,

the west side of the node 100#15, the east side of the

node 100#7 and the east side of the node 100#1

respectively. For example, on the west side of the node

100#15, symbols R1, R2, R3 and R4 indicate that a signal

propagates from the west direction to the east side of

the node 100#7, the east side of the node 100#1, the east

side of the node 100#15 and the east side of the node

100#10 respectively. On the other hand, symbols N1, N2,

N3 and N4 indicate that a signal propagates from the east

direction to the west side of the node 100#10, the west

side of the node 100#15, the west side of the node 100#1

and the west side of the node 100#7 respectively.

On the east side of the node 100#1, symbols R1, R2,

R3 and R4 indicate that a signal propagates from the east

direction to the west side of the node 100#10, the west

side of the node 100#15, the west side of the node 100#1

and the west side of the node 100#7 respectively. On the

other hand, symbols N1, N2, N3 and N4 indicate that a

signal propagates from the west direction to the east

side of the node 100#1, the east side of the node 100#15,

the east side of the node 100#10 and the east side of the

node 100#7 respectively. A line range is defined by using

R and N positions as described above so as to allow

locations of failure occurrences to be determined in case

a plurality of failures occur.

Fig. 47 is a diagram showing a technique to identify a place of occurrence of a failure. The technique shown in Fig. 47 is adopted to identify a place of a failure occurrence in a ring network comprising 8 nodes 100#1 to 100#8. To be more specific, the technique is adopted to identify a place of a failure occurrence by using a RIP table 81#1 in a both-side-end DCP/DCW connection wherein a channel is assigned to transmission lines between the nodes 100#2 and 100#8. In this case, RIP tables 81#2, 81#4, 81#6 and 81#8 of the channel are created on the west side of the node 100#2, the west side of the node 100#4, the east side of the node 100#6 and the east side of the node 100#8 respectively. The node 100#1 is located on the east side of the node 100#2.

Fig. 48 is a diagram showing a technique to determine an east-side N position. An east-side N position is an N position of a failure occurring on a transmission line. The position is identified when information on the failure is received from the east side with the RIP table 81#i provided on the east side. The technique shown in Fig. 48 can be applied to the nodes 100#6 and 100#8 in Fig. 47, which are each a node with a RIP table 81#i provided on the east side thereof. To be

more specific, a truth table shown on the left side of

Fig. 48 is applied to the node 100#6 whereas a truth

table shown on the right side of Fig. 48 is applied to

the node 100#8. On the top row of the truth table,

modified node IDs (RIPs) in the RIP table 81#i are

described. On the left-most column of the truth table, on

the other hand, modified reception IDs (east IDs) in the

RIP table 81#i are described. Characters X-Y described

above the modified node IDs on the top row, where the

character X represents the character E or W and the

character Y represents the character P or S, denote an

east primary node, a west primary node, an east secondary

node or a west secondary node. In this case, if East ID <

RIP ID, the comparison results in a true (T) outcome.

Otherwise, a false (F) comparison result is obtained. A

location forming a line with true and false comparison

results is a location at which a failure has occurred. If

the comparisons result in all false outcomes, the

location of a failure occurrence is between modified node

IDs 0 to 7. Assume that a failure occurs between the

nodes 100#4 and 100#5 for example. In this case, a

modified node ID of 1 for the node ID of 5 of the node

100#5 becomes an east ID in the node 100#6. In accordance

with the technique of determination shown in Fig. 48, the

comparison results in the node 100#6 are T, T, F and T. Thus, by definition shown in Fig. 46, a failure is determined to have occurred at N2.

Fig. 49 is a diagram showing a technique to determine an east-side R position. An east-side R position is an R position of a failure occurring on a transmission line. The position is identified when information on the failure is received from the east side with the RIP table 81#i provided on the east side. The technique shown in Fig. 49 can be applied to the nodes 100#6 and 100#8 in Fig. 47. To be more specific, truth tables shown on the left and right sides of Fig. 49 are applied to the nodes 100#6 and 100#8 respectively. In this case, if East ID ≦ RIP, the comparison results in a true (T) outcome. Otherwise, a false (F) comparison result is obtained. A location forming a line with true and false comparison results is a location at which a failure has occurred. If the comparisons result in all false or true outcomes, the location of a failure occurrence is between modified node IDs 0 to 7. Assume that a failure occurs between the nodes 100#4 and 100#5 for example. In this case, a modified node ID of 2 for the node ID of 4 of the node 100#4 becomes a west ID in the node 100#6. In accordance with the technique of

determination shown in Fig. 49, the comparison results in

the node 100#6 are T, T, F and T. Thus, by definition

shown in Fig. 46, a failure is determined to have

occurred at R3. Thus, in the event of a failure between

the nodes 100#4 and 100#5, results of identification of

failure occurrence locations in the node 100#6 are N2 and

R3.

Fig. 50 is a diagram showing a technique to

determine a west-side N position. A west-side N position

is an N position of a failure occurring on a transmission

line. The position is identified when information on the

failure is received from the west side with the RIP table

81#i provided on the west side. The technique shown in

Fig. 50 can be applied to the nodes 100#2 and 100#4 in

Fig. 47, which are each a node with a RIP table 81#i

provided on the west side thereof. To be more specific,

truth tables shown on the left and right sides of Fig. 50

are applied to the nodes 100#2 and 100#4 respectively. In

this case, if West ID $\leqq$ RIP, the comparison results in a

true (T) outcome. Otherwise, a false (F) comparison

result is obtained. A location forming a line with true

and false comparison results is a location at which a

failure has occurred. If the comparisons result in all

false or true outcomes, the location of a failure

occurrence is between modified node IDs 0 to 7. Assume

that a failure occurs between the nodes 100#4 and 100#5

for example. In this case, a modified node ID of 6 for

the node ID of 4 of the node 100#4 becomes a west ID in

the node 100#2. In accordance with the technique of

determination shown in Fig. 50, the comparison results in

the node 100#2 are F, T, F and F. Thus, by definition

shown in Fig. 46, a failure is determined to have

occurred at N2.

Fig. 51 is a diagram showing a technique to

determine a west-side R position. A west-side R position

is an R position of a failure occurring on a transmission

line. The position is identified when information on the

failure is received from the east side with the RIP table

81#i provided on the west side. The technique shown in

Fig. 51 can be applied to the nodes 100#2 and 100#4 in

Fig. 47, which are each a node with a RIP table 81#i

provided on the west side thereof. To be more specific,

truth tables shown on the left and right sides of Fig. 51

are applied to the nodes 100#2 and 100#4 respectively. In

this case, if East ID < RIP, the comparison results in a

true (T) outcome. Otherwise, a false (F) comparison

result is obtained. A location forming a line with true

and false comparison results is a location at which a

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failure has occurred. If the comparisons result in all false outcomes, the location of a failure occurrence is between modified node IDs 0 to 7. Assume that a failure occurs between the nodes 100#4 and 100#5 for example. In this case, a modified node ID of 5 for the node ID of 5 of the node 100#5 becomes an east ID in the node 100#2. In accordance with the technique of determination shown in Fig. 51, the comparison results in the node 100#2 are F, T, F and F. Thus, by definition shown in Fig. 46, a failure is determined to have occurred at R3. Thus, in the event of a failure between the nodes 100#4 and 100#5, results of identification of failure occurrence locations in the node 100#2 are N2 and R3.

The above description explains a case in which 4 modified node IDs are set in the RIP table 81#i. It should be noted, however, that the number of modified node IDs set in the RIP table 81#i does not have to be 4. That is to say, even with the number of modified node IDs in the RIP table 81#i set at 2 or 3, it is obvious that the above techniques can be applied. The description also holds true of a case in which a squelch table 80#i is used. The techniques can also be applied to a case in which there is a plurality of failure occurrence locations instead of 1 location. Assume, for example,

that the techniques are applicable to a case in which

failures occur between the nodes 100#4 and 100#5 as well

as between the nodes 100#6 and 100#7. In the node 100#6,

a modified node ID of 1 for a node ID of 5 becomes an

east ID whereas a modified node ID of 7 for a node ID of

7 becomes a west ID. Thus, results of identification of

failure occurrence locations are N2 and R4. Since the

failure-occurrence-location-identifying unit 86#i based

on the squelch table 80#i or the RIP table 81#i indicates

the N and R locations, the switching control unit 88#i

executes switching control for each channel as follows:

1: For a case in which the squelch table 80#i is used

In the case of a normal BLSR multiplexing apparatus,

for example, in a node other than the secondary node

100#i of the DCP/DTP connection, the switching control

described below is executed by using the squelch table

80#i as follows:

1-1: If nodes indicated by a modified source ID and a

modified destination ID, which are set in the squelch

table 80#i, can be connected to each other by working

lines by-passing the N and R locations of on the failing

transmission lines, no switching operation is carried out.

1-2: If nodes indicated by a modified source ID and a

modified destination ID, which are set in the squelch

table 80#i, cannot be connected to each other by working
lines, but can be connected by protection lines by-
passing the N and R locations of on the failing
transmission lines, the transmission is switched to the
protection lines like the case of the failures shown in
Figs. 32A, 32C, 37A and 37B.

1-3: If nodes indicated by a modified source ID and a
modified destination ID, which are set in the squelch
table 80#i, cannot be connected to each other by lines
by-passing the N and R locations of on the failing
transmission lines, a squelching operation is carried out
like the case of the failures shown in Figs. 32B and 37C.

2: For a case in which the RIP table 81#i is used

In a secondary node serving as a normal BLSR
multiplexing apparatus in a DCP/DTP connection and a node
serving as a submarine BLSR multiplexing apparatus adding
and dropping signals, for example, the switching control
described below is executed by using the RIP table 81#i
as follows:

2-1: The N and R locations of on the failing transmission
lines as well as modified node IDs and path information,
which are set in the RIP table 81#i, are used as a basis
for forming a judgment as to whether or not the ring
network can be rescued from a generated failure. If the

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ring network cannot be rescued from a generated failure, no switching control is executed.

2-2: The N and R locations of on the failing transmission lines as well as modified node IDs and path information, which are set in the RIP table 81#i, are used as a basis for forming a judgment as to whether or not a failure has occurred on a working line. If no failure has occurred on a working line, no switching control is executed.

2-3: The N and R locations of on the failing transmission lines as well as modified node IDs and path information, which are set in the RIP table 81#i, are used as a basis for forming a judgment as to whether or not a failure has occurred on a protection line even though the occurrence of a failure on a working line is determined. If failures have occurred on working and protection lines, switching operations are carried out in dependence on whether the path information indicates that the implementation of connection is a normal, DTW, DCP one-side-end, DCW one-side-end, DCP both-side-end, DCW both-side-end or DTP connection. As an example, switching control for the one-side-end DCP connection and for the one-side-end DCW connection is explained as follows.

Figs. 52A and 52B are diagrams showing switching control in the event of a failure between primary and

secondary nodes for a one-side-end DCP connection. To be
more specific, Fig. 52A is a diagram showing flows of
signals with no failure occurring between the primary and
secondary nodes. On the other hand, Fig. 52B is a diagram
showing a switching operation carried out in the event of
a failure between the primary and secondary nodes. In
Figs. 52A and 52B, a node 100#2 is a terminal node, a
node 100#3 is a primary node and a terminal node 100#4 is
a secondary node whereas symbols W and E denote the west
and east directions respectively. As shown in Fig. 52A,
when there is no failure on a transmission line between
the primary node 100#3 and the secondary node 100#4, in
the west direction, the terminal node 100#2 adds a
channel signal to a working line, the primary node 100#3
drops the signal from the working line as well as
continues the signal to a protection line and the
secondary node 100#4 drops the signal from the protection
line. In the east direction, on the other hand, the
secondary node 100#4 adds a signal to protection line,
the primary node 100#3 selects either the signal coming
from the protection line or a signal received from an
adjacent ring network, adding the selected signal to a
working line, and the terminal node 100#2 drops the
signal from the working line. When failures occur on

transmission lines between the primary node 100#3 and the secondary node 100#4, switching operations are carried out as follows.

As shown in Fig. 52B, in the west direction, the terminal node 100#2 passes on a signal propagating through a protection line as well as adds a signal to a working line, the primary node 100#3 drops a signal from the working line as well as passes on the signal propagating through the protection line and the secondary node 100#4 passes on the signal propagating through the protection line. In the east direction, on the other hand, the secondary node 100#4 passes on a signal propagating through a protection line, the primary node 100#3 passes on the signal propagating through the protection line as well as adds a signal from the adjacent ring network to a working line and the terminal node 100#2 drops the signal from the working line.

Figs. 53A and 53B are diagrams showing switching control in the event of a failure between primary and secondary nodes for a one-side-end DCW connection. To be more specific, Fig. 53A is a diagram showing flows of signals with no failure occurring between the primary and secondary nodes. On the other hand, Fig. 53B is a diagram showing a switching operation carried out in the event of

a failure between the primary and secondary nodes. In Figs. 53A and 53B, a node 100#6 is a terminal node, a node 100#7 is a primary node and a terminal node 100#8 is a secondary node whereas symbols W and E denote the west and east directions respectively.

As shown in Fig. 53A, when there is no failure on a transmission line between the primary node 100#7 and the secondary node 100#8, in the west direction, the terminal node 100#6 adds a channel signal to a working line, the primary node 100#7 drops the signal from the working line as well as continues the signal to a working line and the secondary node 100#8 drops the signal from the working line. In the east direction, on the other hand, the secondary node 100#8 adds a signal to working line, the primary node 100#7 selects either the signal coming from the working line or a signal received from an adjacent ring network, adding the selected signal to a working line, and the terminal signal 100#6 drops the signal from the working line. When failures occur on transmission lines between the primary node 100#7 and the secondary node 100#8, switching operations are carried out as follows.

As shown in Fig. 53B, in the west direction, the terminal node 100#6 adds a signal to a working line and

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provides a bridge between the working line and a protection line in the opposite direction. The primary node 100#7 drops the signal from the working line as well as continues this signal to a working line. The secondary node 100#8 adds a signal from the adjacent ring network to a protection line by way of a bridge. In the east direction, on the other hand, the secondary node 100#8 drops a signal from a protection line coming from the west direction and adds a signal to a protection line. The primary node 100#7 adds a signal obtained as a result of selection of either a signal propagating through a working line or a signal from the adjacent ring network to a working line. The terminal node 100#6 selects a signal from a protection line to the west direction or the signal from the working line to the east direction and drops the selected signal.

The operation of the transmission apparatus 56#i shown in Fig. 11 is explained as follows.

1: Classification of cross-connect information

Fig. 54 is a flowchart of classification of cross-connect information. As shown in Fig. 54, the flowchart begins with a step S2 at which the cross-connect-classifying unit 72#i inputs cross-connect information from the user interface unit 70#i. The cross-connect

information includes information on a channel, a transmission, a direction and a line. The information on a transmission indicates whether the transmission adds, drops or passes through a signal. The information on a direction indicates whether a signal is transmitted in the east or west direction. The information on a line indicates whether the transmission line is a working or protection line. The flow in the flowchart then goes on to a step S4 to form a judgment as to whether or not the operation to input the cross-connect information has been completed. If the outcome of the judgment indicates that the operation to input the cross-connect information has been completed, the flow in the flowchart goes on to a step S6. If the outcome of the judgment indicates that the operation to input the cross-connect information has not been completed, on the other hand, the flow in the flowchart goes back to the step S2. At the step S6, the cross-connect-classifying unit 72#i forms a judgment as to whether the cross-connect information was input once or twice. If the outcome of the judgment indicates that the cross-connect information was input twice, the flow in the flowchart goes on to a step S8. If the outcome of the judgment indicates that the cross-connect information was input once, on the other hand, the flow in the

flowchart goes on to a step S12. At the step S8, one of

the 2 pieces of cross-connect information including

information on a working line is selected. At the next

step S10, the cross-connect information is determined to

pertain to one of the categories shown in Fig. 13.

Likewise, at the step S12, the cross-connect information

is determined to pertain to one of the categories shown

in Fig. 13.

2: Collection of cross-connect categories

Fig. 55 is a diagram showing the structure of

transmitted data including a cross-connect category. As

shown in Fig. 55, the transmitted data consists of

typically 8 bits D0 to D7. The bits D7 and D6 are a code

representing token control. Typically, D7 and D6 values

of (0, 0), (0, 1), (1, 0) and (1, 1) indicate a UNEQ code,

a ring establishment code, a token transfer code and a

token code respectively. The UNEQ code is a code for

triggering construction of a table. The ring

establishment code is a code for establishing a token

ring. The token transfer code is a code for transferring

a token. The token code is a code for indicating

transmission of a cross-connect category.

The bits D5 and D4 are a code representing a cross-

connect category. Typically, D5 and D4 values of (0, 0),

(0, 1), (1, 0) and (1, 1) indicate a category of adding a signal to a working line, adding a signal to a protection line, dropping a signal from a working line and dropping a signal from a protection line respectively.

The bits D3 to D0 are a node ID in the range 0 to 15. The cross-connect category of the bits D5 and D4 and the node ID of the bits D3 to D0 are transmitted along with one of the token control codes of the bits D7 and D6 except the UNEQ code and the token transfer code.

Fig. 56 is a diagram showing a sequence to construct a table. Fig. 57 is a diagram showing a chart to construct a table. In Figs. 56 and 57, nodes 100#A, 100#B, 100#C, 100#D and 100#E are an east-end station, an intermediate station, a through station, an intermediate station and a west-end station respectively. Fig. 58 shows a flowchart representing a procedure to construct a table for an east-end station. Fig. 59 shows a flowchart representing a procedure to construct a table for an intermediate station. Fig. 60 shows a flowchart representing a procedure to construct a table for a through station. Fig. 61 shows a flowchart representing a procedure to construct a table for a west-end station.

When the east-end station 100#A receives a UNEQ code from the west-end station 100#E, as shown in a

diagram (1) of Fig. 56 and a diagram (1) of Fig. 57, at

the first step S20 of the flowchart shown in Fig. 58, the

east-end station 100#A sets a ring establishment code, a

cross-connect category and a node ID in bits D0 to D7 of

an overhead, which are shown in Fig. 55, and transmits

the codes to the west side. At the next step S22, a table

is initialized. At the next step S24, the cross-connect

category is stored in a stack.

At the first step S50 of the flowchart shown in Fig.

59, the intermediate station 100#B forms a judgment as to

whether or not a ring establishment code has been

received. If the outcome of the judgment indicates that a

ring establishment code has been received, the flow of

the procedure goes on to a step S52. If the outcome of

the judgment indicates that a ring establishment code has

not been received, on the other hand, the intermediate

station 100#B enters a wait state, repeating the

formation of the judgment at the step S50. Since a ring

establishment code has been received in this case, the

flow of the procedure goes on to the step S52. At the

step S52, a stack table is initialized. At the next step

S54, the cross-connect category and the node ID are

stored in the stack table. At the next step S55, the ring

establishment code is transferred.

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At the first step S90 of the flowchart shown in Fig. 60, the through station 100#C forms a judgment as to whether or not information on a token has been received. If the outcome of the judgment indicates that information on a token has been received, the flow of the procedure goes on to a step S92. If the outcome of the judgment indicates that information on a token has not been received, on the other hand, the through station 100#C enters a wait state, repeating the formation of the judgment at the step S90. Since the information on a token has been received in this case, the flow of the procedure goes on to the step S92 to form a judgment as to whether or not a ring establishment code has been received. If the outcome of the judgment indicates that a ring establishment code has been received, the flow of the procedure goes on to a step S94. Since a ring establishment code has been received in this case, the flow of the procedure goes on to the step S94 at which a stack table is initialized. At the next step S96, the cross-connect category and the node ID are stored in the stack table. At the next step S98, data is transferred.

Much like the intermediate station 100#B, the intermediate station 100#D receives the ring establishment code and stores the cross-connect category

and the node ID in a stack, and then transfers the ring
establishment code.

At the first step S120 of the flowchart shown in
Fig. 61, the west-end station 100#E completes the
operation to input cross-connect information, identifying
a cross-connect category and transmits a UNEQ code for
triggering construction of a table. After receiving the
UNEQ code, at the next step S122, the east-end station
100#A forms a judgment as to whether or not the
transmitted ring establishment code has been received. If
the outcome of the judgment indicates that the
transmitted ring establishment code has been received,
the flow of the procedure goes on to a step S124. If the
outcome of the judgment indicates that the transmitted
ring establishment code has not been received, on the
other hand, the west-end station 100#E enters a wait
state, repeating the formation of the judgment at the
step S120. Since the ring establishment code has been
received in this case, the flow of the procedure goes on
to the step S124 at which a stack table is initialized.
At the next step S126, the cross-connect category and the
node ID are stored in the stack table. At the next step
S128, the ring establishment code is transmitted to the
east side. This ring establishment code is received by

the east-end station 100#A after passing through the intermediate station 100#D, a through station 100#C and the intermediate station 100#B.

At a step S26 of the flowchart shown in Fig 58, the east-end station 100#A forms a judgment as to whether or not the transmitted ring establishment code has been received. If the outcome of the judgment indicates that the transmitted ring establishment code has been received, the flow of the procedure goes on to a step S28. If the outcome of the judgment indicates that the transmitted ring establishment code has not been received, on the other hand, the east-end station 100#A enters a wait state, repeating the formation of the judgment at the step S26. As shown in a diagram (2) of Fig. 56 and a diagram (2) of Fig. 57, at the step S28, the east-end station 100#A transmits a token transfer code.

At a step S56 of the flowchart shown in Fig. 59, the intermediate station 100#B forms a judgment as to whether or not a token has been received. If the outcome of the judgment indicates that a token has been received, the flow of the procedure goes on to a step S72. If the outcome of the judgment indicates that a token has not been received, on the other hand, the flow of the procedure goes on to a step S58. Since a token transfer

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code has been received in this case, the flow of the procedure goes on to the step S58 to form a judgment as to whether or not the token transfer code has been received. If the outcome of the judgment indicates that the token transfer code has been received, the flow of the procedure goes on to a step S60. Since the token transfer code has been received in this case, the flow of the procedure goes on to the step S60. As shown in a diagram (3) of Fig. 56 and a diagram (3) of Fig. 57, at the step S60, the token, namely, the token code, the cross-connect category and the node ID, is transmitted.

To put it in detail, the token is transmitted to the east-end station 100#A, the through station 100#C, the intermediate station 100#D and the west-end station 100#E. At a step S100 of the flowchart shown in Fig. 60, the through station 100#C forms a judgment as to whether or not a token has been received. If the outcome of the judgment indicates that a token has not been received, the flow of the procedure goes on to a step S109. If the outcome of the judgment indicates that a token has been received, on the other hand, the flow of the procedure goes on to a step S102. At the step S102, if the node of the cross-connect category stored in the stack immediately before is a broadcasting station, the

received cross-connection category is stored in the stack,
overwriting the cross-connect category stored in the
stack immediately before. If the node of the cross-
connect category stored in the stack immediately before
is not a broadcasting station, on the other hand, the
received cross-connection category is stored in the stack
after the cross-connect category stored in the stack
immediately before. At the next step S106, the
implementation of connection is checked. The flow of the
procedure then goes on to a step S108 to form a judgment
as to whether or not a connection error exists. If the
outcome of the judgment indicates that a connection error
does not exist, the flow of the procedure goes on to the
step S109 at which data is transferred. Then, the flow of
the procedure goes back to the step S90. If the outcome
of the judgment indicates that a connection error exists,
on the other hand, the flow of the procedure goes on to a
step S110 at which a warning is output. Then, the
processing is ended.

At a step S56 of the flowchart shown in Fig. 59,
the intermediate station 100#D forms a judgment as to
whether or not a token has been received. If the outcome
of the judgment indicates that a token has been received,
the flow of the procedure goes on to a step S72. At the

step S72, if the node of the cross-connect category

stored in the stack immediately before is a broadcasting

station, the received cross-connection category is stored

in the stack, overwriting the cross-connect category

stored in the stack immediately before. If the node of

the cross-connect category stored in the stack

immediately before is not a broadcasting station, on the

other hand, the received cross-connection category is

stored in the stack after the cross-connect category

stored in the stack immediately before. At the next step

S74, the implementation of connection is checked. The

flow of the procedure then goes on to a step S76 to form

a judgment as to whether or not a connection error exists.

If the outcome of the judgment indicates that a

connection error does not exist, the flow of the

procedure goes on to a step S78 at which data is

transferred. Then, the flow of the procedure goes on to a

step S80 to form a judgment as to whether or not a token

has been received from the west-end station 100#E. If the

outcome of the judgment indicates that a token has been

received from the west-end station 100#E, the processing

is ended. If the outcome of the judgment indicates that a

token has not been received from the west-end station

100#E, on the other hand, the flow of the procedure goes

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back to the step S56. If the outcome of the judgment

formed at the step S76 indicates that a connection error

exists, on the other hand, the flow of the procedure goes

on to a step S82 at which a warning is output. Then, the

processing is ended.

At a step S130 of the flowchart shown in Fig. 61,

the intermediate station 100#E forms a judgment as to

whether or not a token has been received. If the outcome

of the judgment indicates that a token has been received,

the flow of the procedure goes on to the step S132. At

the step S132, if the node of the cross-connect category

stored in the stack immediately before is a broadcasting

station, the received cross-connection category is stored

in the stack, overwriting the cross-connect category

stored in the stack immediately before. If the node of

the cross-connect category stored in the stack

immediately before is not a broadcasting station, on the

other hand, the received cross-connection category is

stored in the stack after the cross-connect category

stored in the stack immediately before. At the next step

S134, the implementation of connection is checked. The

flow of the procedure then goes on to a step S136 to form

a judgment as to whether or not a connection error exists.

If the outcome of the judgment indicates that a

connection error does not exist, the flow of the
procedure goes back to the step S130. If the outcome of
the judgment indicates that a connection error exists, on
the other hand, the flow of the procedure goes on to a
step S137 at which a warning is output.

At the step S32 of the flowchart shown in Fig. 58,
if the node of the cross-connect category stored in the
stack immediately before is a broadcasting station, the
east-end station 100#A does not stores the received
cross-connection category in the stack but stores the
cross-connect of its own in the stack, overwriting the
cross-connect category stored in the stack immediately
before. If the node of the cross-connect category stored
in the stack immediately before is not a broadcasting
station, on the other hand, the east-end station 100#A
stores the received cross-connection category in the
stack after the cross-connect category stored in the
stack immediately before. At the next step S34, the
implementation of connection is checked. The flow of the
procedure then goes on to a step S136 to form a judgment
as to whether or not a connection error exists. If the
outcome of the judgment indicates that a connection error
does not exist, the flow of the procedure goes on to a
step S36 to form a judgment as to whether or not a token

has been received from the west-end station. If the outcome of the judgment indicates that a token has been received from the west-end station, the processing is ended. If the outcome of the judgment indicates that a token has not been received from the west-end station, on the other hand, the flow of the procedure goes back to a step S30. If the outcome of the judgment formed at the step S136 indicates that a connection error exists, on the other hand, the flow of the procedure goes on to a step S38 at which a warning is output. Then, the processing is ended.

At a step S62 of the flowchart shown in Fig. 59, if the node of the cross-connect category stored in the stack immediately before is a broadcasting station, the intermediate station 100#B does not stores the received cross-connection category in the stack but stores the cross-connect of its own in the stack, overwriting the cross-connect category stored in the stack immediately before. If the node of the cross-connect category stored in the stack immediately before is not a broadcasting station, on the other hand, the east-end station 100#A stores the received cross-connection category in the stack after the cross-connect category stored in the stack immediately before. At the next step S64, the

implementation of connection is checked. The flow of the

procedure then goes on to a step S66 to form a judgment

as to whether or not a connection error exists. If the

outcome of the judgment indicates that a connection error

does not exist, the flow of the procedure goes back to

the step S56 by way of a step S68. If the outcome of the

judgment indicates that a connection error exists, on the

other hand, the flow of the procedure goes on to a step

S70 at which a warning is output. Then, the processing is

ended. At the step 68, a token transfer code is

transmitted as shown in a diagram (3) of Fig. 56 and a

diagram (4) of Fig. 57.

Thereafter, the intermediate station 100#D receives

the token transfer code and transmits a token code as

shown in a diagram (5) of Fig. 56 in the same way. The

east-end station 100#A, the intermediate station 100#B,

the through station 100#C, the intermediate station 100#D

and the west-end station 100#E store a cross-connect

category in the stack in the same way. The intermediate

station 100#D transmits a token transfer code as shown in

a diagram (6) of Fig. 56. The west-end station 100#E

receives the token transfer code as shown in a diagram

(4) of Fig. 55 and transmits the token transfer code as

shown in a diagram (7) of Fig. 56. The east-end station

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100#A, the intermediate station 100#B, the through

station 100#C, the intermediate station 100#D and the

west-end station 100#E store a cross-connect category and

a node ID in the stack in the same way. As such, the

operation to collect cross-connect categories is ended.

3: Creation of a squelch table 80#i

Fig. 62 shows a flowchart representing a procedure

to create a squelch table 80#i. As shown in the figure,

the flowchart begins with a step S160 to form a judgment

as to whether or not to create a squelch table 80#i for a

channel related to a cross-connect category stored in a

stack. A squelch table 80#i is typically created in a

node passed through by a normal BLSR working line and a

primary node of the DTW implementation of connection. If

the outcome of the judgment indicates that a squelch

table 80#i is not to be created, the procedure is ended.

If the outcome of the judgment indicates that a squelch

table 80#i is to be created, on the other hand, the flow

of the procedure goes on to a step S162 at which one of

the implementations of connection of Figs. 19 to 26

corresponding to a cross-connect category stored in the

stack is identified. The flow of the procedure then goes

on to a step S164 at which the identified implementation

of connection is recognized. If the implementation of

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connection is a normal add and drop connection or a DTW
connection, the flow of the procedure goes on to a step
S166 at which modified node IDs of both the end stations
are set in the squelch table 80#i. If the implementation
of connection is a DCP one-side-end connection, the flow
of the procedure goes on to a step S168 at which modified
node IDs of the terminal stations at both ends and
secondary stations are set in the squelch table 80#i. If
the implementation of connection is a DCP both-side-end
connection, the flow of the procedure goes on to a step
S170 at which modified node IDs of the secondary stations
at both ends are set in the squelch table 80#i. If the
implementation of connection is a DCW one-side-end
connection, the flow of the procedure goes on to a step
S172 at which modified node IDs of the terminal stations
at both ends and secondary stations are set in the
squelch table 80#i. If the implementation of connection
is a DCW both-side-end connection, the flow of the
procedure goes on to a step S174 at which modified node
IDs of the secondary stations at both ends are set in the
squelch table 80#i. If the implementation of connection
is a DTP one-side-end connection, the flow of the
procedure goes on to a step S176 at which modified node
IDs of nodes on protection-line segments of DTP paths

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between nodes passed through by working lines are set in the squelch table 80#i.

4: Creation of a RIP table 81#i

Fig. 63 shows a flowchart representing a procedure to create a RIP table 81#i. As shown in the figure, the flowchart begins with a step S180 to form a judgment as to whether or not to create a RIP table 81#i for a channel related to a cross-connect category stored in a stack. A RIP table 81#i is typically created in a secondary node of a normal BLSR DCP/DTP connection and a node including a submarine BLSR add/drop connection. If the outcome of the judgment indicates that a RIP table 81#i is not to be created, the procedure is ended. If the outcome of the judgment indicates that a RIP table 81#i is to be created, on the other hand, the flow of the procedure goes on to a step S182 at which one of the implementations of connection of Figs. 19 to 26 corresponding to a cross-connect category stored in the stack is identified. The flow of the procedure then goes on to a step S184 at which the identified implementation of connection is recognized. If the implementation of connection is a normal add and drop connection or a DTW connection, the flow of the procedure goes on to a step S186 at which node IDs of (-, A, B, -) are set in the RIP

table 81#i where the symbols A and B are each a node ID
stored in a stack whereas the symbol - represents the
aforementioned special value indicating no setting. Then,
the flow of the procedure goes on to a step S188 at which
path information of (-, -, -, -) is set in the RIP table
81#i.

If the implementation of connection is a DCP one-
side-end connection, the flow of the procedure goes on to
a step S190 at which node IDs of (A, B, C, -)/(-, A, B,
C) are set in the RIP table 81#i where the symbols A, B
and C are each a node ID stored in a stack whereas the
symbol - represents no setting. Then, the flow of the
procedure goes on to a step S192 at which path
information of (P, DCx, -, -)/(-, -, DCx, P) is set in
the RIP table 81#i.

If the implementation of connection is a DCP both-
side-end connection, the flow of the procedure goes on to
a step S194 at which node IDs of (A, B, C, D) are set in
the RIP table 81#i where the symbols A, B, C and D are
each a node ID stored in a stack whereas the symbol -
represents no setting. Then, the flow of the procedure
goes on to a step S196 at which path information of (P,
DCx, DCx, P) is set in the RIP table 81#i.

If the implementation of connection is a DCW one-

side-end connection, the flow of the procedure goes on to a step S198 at which node IDs of (A, B, C, -)/(-, A, B, C) are set in the RIP table 81#i where the symbols A, B and C are each a node ID stored in a stack whereas the symbol - represents no setting. Then, the flow of the procedure goes on to a step S200 at which path information of (W, DCx, -, -)/(-, -, DCx, W) is set in the RIP table 81#i.

If the implementation of connection is a DCW both-side-end connection, the flow of the procedure goes on to a step S202 at which node IDs of (A, B, C, D) are set in the RIP table 81#i where the symbols A, B, C and D are each a node ID stored in a stack whereas the symbol - represents no setting. Then, the flow of the procedure goes on to a step S204 at which path information of (W, DCx, DCx, W) is set in the RIP table 81#i.

If the implementation of connection is a DTP one-side-end connection, the flow of the procedure goes on to a step S206 at which node IDs of (A, B, C, -)/(-, A, B, C) are set in the RIP table 81#i where the symbols A, B and C are each a node ID stored in a stack whereas the symbol - represents no setting. Then, the flow of the procedure goes on to a step S208 at which path information of (P, DT, -, -)/(-, -, DT, P) is set in the

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RIP table 81#i.

At the next step S210, node IDs set in the RIP
table 81#i are modified. At the next step S212, the RIP
table 81#i is provided on the east side if a signal is
added to the east side or dropped from the east side. On
the other hand, the RIP table 81#i is provided on the
west side if a signal is added to the west side or
dropped from the west side.

5: Identification of the location of a failure occurrence

Fig. 64 shows a flowchart representing a procedure
to identify the location of occurrence of a failure. In
the event of a failure on a transmission line, both the
nodes connected to the transmission line each transmits
information on the failure including the node ID of the
failing node by inserting the information into typically
K1 and K2 bytes of an overhead. The nodes are each
referred to each a span node. If failures occur on a
plurality of transmission lines at the same time,
information on a failure is transmitted from a plurality
of nodes. As shown in the figure, the flowchart begins
with a step S210 at which information on a failure is
received. The flow of the procedure then goes on to a
step S212 to form a judgment as to whether the node ID
included in the information on the failure indicates that

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the information has been received from the east or west side. If the outcome of the judgment indicates that the node ID has been received from the west side, the flow of the procedure goes on to a step S228. If the outcome of the judgment indicates that the node ID has been received from the east side, on the other hand, the flow of the procedure goes on to a step S214 to form a judgment as to whether the RIP table 81#i is provided on the east or west side. If the outcome of the judgment indicates that the RIP table 81#i is provided on the west side, the flow of the procedure goes on to a step S216. If the outcome of the judgment indicates that the RIP table 81#i is provided on the east side, on the other hand, the flow of the procedure goes on to a step S222.

At the step S216, the received node ID is modified. The flow of the procedure then goes on to a step S218 to form a judgment as to whether or not the relation east ID < the modified node ID (RIP) set in the RIP table 81#i holds true, and sets a true (T) logic value indicating that the relation holds true or a false (F) logic value indicating otherwise. At the next step S220, a location forming a line with the truth values T and F or the location of a RIP IDO-n where the symbol n is the number of nodes composing the ring network is determined as a

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west-side R position.

At the step S222, the received node ID is modified. The flow of the procedure then goes on to a step S224 to form a judgment as to whether or not the relation east ID < the RIP holds true, and sets a true (T) logic value indicating that the relation holds true or a false (F) logic value indicating otherwise. At the next step S226, a location forming a line with the truth values T and F or the location of a RIP IDO-n where the symbol n is the number of nodes composing the ring network is determined as an east-side N position.

As described above, if the outcome of the judgment formed at the step S212 indicates that the node ID has been received from the west side, the flow of the procedure goes on to the step S228 to form a judgment as to whether the RIP table 81#i is provided on the east or west side. If the outcome of the judgment indicates that the RIP table 81#i is provided on the west side, the flow of the procedure goes on to a step S230. If the outcome of the judgment indicates that the RIP table 81#i is provided on the east side, on the other hand, the flow of the procedure goes on to a step S236.

At the step S230, the received node ID is modified. The flow of the procedure then goes on to a step S232 to

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form a judgment as to whether or not the relation west ID $\leq$ the RIP holds true, and sets a true (T) logic value indicating that the relation holds true or a false (F) logic value indicating otherwise. At the next step S234, a location forming a line with the truth values T and F or the location of a RIP IDO-n where the symbol n is the number of nodes composing the ring network is determined as a west-side N position.

At the step S236, the received node ID is modified. The flow of the procedure then goes on to a step S238 to form a judgment as to whether or not the relation west ID $\leq$ the RIP holds true, and sets a true (T) logic value indicating that the relation holds true or a false (F) logic value indicating otherwise. At the next step S240, a location forming a line with the truth values T and F or the location of a RIP IDO-n where the symbol n is the number of nodes composing the ring network is determined as a west-side R position.

Then, the flow of the procedure goes on from the step S220, S226, S234 or S240 to a step S252 to form a judgment as to whether or not the R or N position has been determined. If the outcome of the judgment indicates that the R or N position has not been determined, the flow of the procedure goes back to the step S210. If the

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outcome of the judgment indicates that the R or N

position has been determined, on the other hand, the

processing is ended.

6: Switching in the event of a failure

Fig. 65 shows a flowchart representing a procedure

of a switching operation carried out in the event of a

failure. As shown in the figure, the flowchart begins

with a step S260 at which the location of occurrence of a

failure is determined from the N and R positions. Then,

the flow of procedure goes on to a step S262 to form a

judgment as to whether to use the squelch table 80#i or

the RIP table 81#i. If the outcome of the judgment

indicates that the squelch table 80#i is to be used, the

flow of the procedure goes on to a step S264. If the

outcome of the judgment indicates that the RIP table 81#i

is to be used, on the other hand, the flow of the

procedure goes on to a step S270. At the step S264, the

transmission is switched to a protection line. The flow

of the procedure then goes on to a step S266 to form a

judgment as to whether or not it is possible to establish

a connection between source and destination nodes, which

are indicated by a modified source node ID and a modified

destination node ID respectively. The modified source

node ID and the modified destination node ID are set in

the squelch table 80#i. If the outcome of the judgment indicates that it is possible to establish a connection between source and destination nodes, the processing is ended. If the outcome of the judgment indicates that it is not possible to establish a connection between source and destination nodes, on the other hand, the flow of the procedure goes on to a step S268 at which a squelching operation is carried out.

As described above, when the RIP table 81#i is to be used, the flow of the procedure goes on to a step S270 to form a judgment as to whether or not a failure has occurred on a transmission line between a terminal node or a primary node and a primary node. If the outcome of the judgment indicates that a failure has occurred on a transmission line between a terminal node or a primary node and a primary node, the flow of the procedure goes on to a step S272 at which the transmission is switched to a protection line. If the outcome of the judgment indicates that no failure has occurred on a transmission line between a terminal node or a primary node and a primary node, on the other hand, the flow of the procedure goes on to a step S274. At the step S274, the implementation of connection is recognized by referring to the RIP table 81#i. At the next step S276, a switching

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operation is carried out in accordance with the recognized implementation of connection. If the implementation of connection is a submarine DCP connection, for example, the switching operations shown in Fig. 52B are carried out. If the implementation of connection is a submarine DCW connection, on the other hand, the switching operations shown in Fig. 53B are carried out. As such, switching operations are carried out in accordance with a variety of implementations of connection including the DCP/DCW submarine BLSR and DTP connections and the normal BLSR connection.

7: Table reconstruction

Figs. 66A to 66D are each a diagram showing typical reconstruction of a table. The configuration of a built network may be changed in some cases. Assume that squelch tables 80#i and RIP tables 81#i between a node 100#A and a node 100#E shown in Fig. 66A have been created in accordance with the procedures explained above, and assume that the configuration of the network is changed. The configuration of the network is changed by modifying cross-connect information. For example, a node 100#B, which has been operating as a through-only node so far, is changed to a DCW primary node having a cross connect for adding and dropping a signal as shown in Fig. 66B, or

changed to an east-end, west-end or through station. In this case, the squelch tables 80#i and the RIP tables 81#i are reconstructed.

Fig. 67 shows a flowchart representing a procedure to reconstruct tables. The flowchart shown in Fig. 67 begins with a step S290 to form a judgment as to whether or not the configuration of the network has been changed. If the outcome of the judgment indicates that network has not been changed, the processing is just ended. If the outcome of the judgment indicates that network has been changed, on the other hand, the flow of the procedure goes on to a step S292 to identify the type of the change in configuration. If a node has been changed to an east-end station, the procedure goes on to a step S294 at which a ring establishment code is transmitted and, at the next step S296, processing according to procedure (2) shown in Fig. 56 is carried out. In addition, the squelch tables 80#i and the RIP tables 81#i related to the channel are reconstructed. If a node has been changed to a UNEQ station with no cross connect, the procedure goes on to a step S298 at which all 0s are transmitted. By the same token, if a node has been changed to a west-end station, the procedure goes on to a step S300 at which all 0s are transmitted. If a node has been changed to an

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intermediate station as shown in Fig. 66B, the procedure

goes on to a step S302 at which, similarly, all 0s are

transmitted. If a node has been changed to a through

station, the procedure goes on to a step S304 at which,

likewise, all 0s are transmitted.

The flow of the procedure then goes on from the

step S298, S300, S302 and S304 to a step S306 form a

judgment as to whether or not the east-end station has

received data other than a token. If the outcome of the

judgment indicates that the east-end station has received

data other than a token, the flow of the procedure goes

on to a step S307. If the outcome of the judgment

indicates that the east-end station has not received data

other than a token, on the other hand, the flow of the

procedure goes back to the step S306, entering a wait

state by repeating the formation of the judgment. At the

step S307, processing according to procedure (1) shown in

Fig. 56 is carried out and, in addition, the squelch

tables 80#i and the RIP tables 81#i related to the

channel are reconstructed as shown in Figs. 66C and 66D.

In accordance with the embodiments described above,

tables are created and switching control is executed in

the event of a failure in dependence on the

implementation of connection so that a switching

operation based on the implementation of connection can be carried out. In addition, by formation of a proper judgment as to whether or not to carry out a squelching operation in accordance with the implementation of connection in the event of a failure, an appropriate operation to rescue the network from the failure can be performed. Furthermore, in accordance with the present invention, since connections of line definitions according to implementations of connection are checked, reliability is further improved.

As described above, tables are created and switching control is executed in the event of a failure in dependence on the implementation of connection so that a switching operation based on the implementation of connection can be carried out. In addition, by formation of a proper judgment as to whether or not to carry out a squelching operation in accordance with the implementation of connection in the event of a failure, an appropriate operation to rescue the network from the failure can be performed. Furthermore, in accordance with the present invention, since connections of line definitions according to implementations of connection are checked, reliability is further improved.

It should be noted that the present invention is

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not limited to the details of the preferred embodiments

described above. The scope of the present invention is

defined by the following appended claims, and all changes

and modifications falling within the scope of the claims

are therefore to be embraced by the invention.